

1 CHAPTER 3 - AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

2 3.1 INTRODUCTION AND BACKGROUND

3 This chapter presents both the affected environment and environmental consequences, as
4 required by the National Environmental Policy Act (NEPA). It is organized by resource topic,
5 with the status of the affected environment described first, followed by the impacts of each
6 alternative described within each resource section. Each resource has defined the area of
7 analysis consistent with where that resource may experience effects.

8 The affected environment sections provide a description of different aspects of the human
9 environment that may be affected by the No Action Alternative and four Multiple Objective
10 Alternatives (MOs). The environmental consequences sections provide a description of the
11 impact assessment methodologies, and potential direct and indirect effects. Many natural
12 resources are of importance both currently and historically to Native American tribes. As such,
13 effects to these resources, and relationships to tribal interests, are discussed within each
14 applicable resource section as well as in sections such as Indian Trust Assets, Tribal Perspective
15 and Tribal Interests, and Cultural Resources.

16 Effects can be short-term or long-term, and beneficial or adverse. The analysis focuses only on
17 those resources of the human and natural environment which are likely to be affected by the
18 alternatives under consideration. The time scale used for the comparative analysis of the four
19 MOs to the No Action Alternative is a 25-year period from 2020 to 2045. For the purposes of
20 conducting the economic analysis, a 50-year period of analysis is used to better capture the full
21 array of changing costs and investments, and represent the total costs, benefits, and tradeoffs
22 being evaluated in each of the MOs. This economic analysis also would be able to distinguish
23 between short-term impacts that may occur during the implementation of alternatives, with
24 initial investments, versus the long-term effects that would occur after implementation is
25 completed. For comparing effects of each alternative, the assumption for analysis in the
26 environmental impact statement (EIS) is that any alternative would be implemented
27 immediately after the Records of Decision (RODs) are signed, recognizing certain structural and
28 mitigation measures may take time to implement. This side-by-side temporal evaluation
29 provides a better point of comparison of effects to resources to inform the analysis and
30 agencies' decisions.

31 There are other factors that influence the effects to resources, and could change the
32 significance determinations of effects. The influence of climate variability could exacerbate
33 effects of an alternative on a resource when cumulatively considered. This is presented in
34 Chapter 4, Climate. The mitigation development process, and proposed mitigation to avoid,
35 minimize, or replace resources, is presented in Chapter 5, Mitigation. Described separately from
36 direct and indirect effects, cumulative effects further considers the effects of each MO in the
37 context of reasonable foreseeable future actions and climate change. This analysis is included in
38 Chapter 6, Cumulative Effects.

39 Consistent with the Council on Environmental Quality's Implementing Regulations for NEPA (40
40 Code of Federal Regulations [C.F.R.] § 1502.16), adverse environmental effects that cannot be

41 avoided, the relationship between short-term uses of the environment and the maintenance
42 and enhancement of long-term productivity, and any irreversible or irretrievable commitments
43 of resources involved in implementation, are presented in separate sections at the end of this
44 chapter.

45 The Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 C.F.R. §
46 1508.8) define the following impact categories:

- 47 • **Direct Effects:** caused by an action included in an alternative and occurring at the same time
48 and place.
- 49 • **Indirect Effects:** caused by an action included in an alternative but would occur later in time
50 or farther removed in distance.
- 51 • **Cumulative Effects:** caused from incremental impact of an action added to other past,
52 present, and reasonably foreseeable future actions.

53 Effects are described as either *beneficial* or *adverse*. Beneficial effects or impacts result in a
54 positive change in the condition of the resource when compared to the No Action Alternative.
55 Adverse effects or impacts result in a negative change in the condition of the resource when
56 compared to the No Action Alternative. Impacts are also described in terms of duration.
57 *Temporary* or *short-term effects* would not persist for the duration of the management action
58 or would only occur for a limited time after implementation of the action (or both). Temporary
59 impacts can be reoccurring such as in the case of flow actions that occur at different intervals
60 over time. *Long-term effects* would be permanent or continuous over the period of analysis.

61 Finally, impacts are described in relation to their significance. The CEQ regulations require
62 consideration of both context and intensity when determining the significance of an effect on a
63 resource. Context means considering the extent of the effect such as in a national, regional, or
64 local setting (see 40 C.F.R. § 1508.27(a)).

65 The following factors can be considered in determining the intensity or severity of an effect (40
66 C.F.R. § 1508.27):

- 67 • Impacts that may be both beneficial and adverse. A significant effect may exist even if the
68 Federal agency believes that on balance the effect will be beneficial.
- 69 • The degree to which the proposed action affects public health or safety.
- 70 • Unique characteristics of the geographic area, such as proximity to historic or cultural
71 resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically
72 critical areas.
- 73 • The degree to which possible effects on the human environment are uncertain or involve
74 unique or unknown risks.
- 75 • The degree to which the action may establish a precedent for future actions with significant
76 effects or represents a decision in principle about a future consideration.
- 77 • Whether the action is related to other actions with individually insignificant but
78 cumulatively significant impacts. Significance exists if it is reasonable to anticipate a

79 cumulatively significant impact on the environment. Significance cannot be avoided by
80 terming an action temporary or by breaking it down into small component parts.

- 81 • The degree to which the action may adversely affect districts, sites, highways, structures, or
82 objects listed in or eligible for listing in the National Register of Historic Places (NRHP) or
83 may cause loss or destruction of important scientific, cultural, or historic resources.
- 84 • The degree to which the action may adversely affect an endangered or threatened species
85 or its habitat that has been determined to be critical under the Endangered Species Act
86 (ESA).
- 87 • Whether the action threatens a violation of Federal, state, or local law or requirements
88 imposed for the protection of the environment.

89 The following descriptors are used in the body of this chapter to describe the level of effect to
90 the various resources affected by the MOs, as compared to the No Action Alternative:

- 91 • **No Effect:** The action would result in no effect as compared to the No Action Alternative.
- 92 • **Negligible Effect:** The effect would not change the resource character in a perceptible way.
93 Negligible is defined as of such little consequences as to not require additional
94 consideration or mitigation.
- 95 • **Minor Effect:** The effect to the resource would be perceptible; however, it may result in a
96 small overall change in resource character.
- 97 • **Moderate Effect:** The effect to the resource would be perceptible and may result in an
98 overall change in resource character.
- 99 • **Major Effect:** The effect to the resource would likely result in a large overall change in
100 resource character.

101 The rationale for why an impact is considered to fall under one of the preceding intensity
102 descriptors is included in each resource section. Statements of significance are supported by
103 text describing the context and intensity of the impact.

104 This section also provides information relevant to the decision process for selecting the
105 Preferred Alternative, described in Chapter 7. The analysis investigates the potential for
106 activities associated with the four MOs to affect the various resources and provides a
107 comparative assessment of each alternative's expected effect on the environment. The
108 assessment of environmental effects is based on a comparison of the No Action Alternative and
109 related MOs; in this case, the four MOs that were brought forward from the alternative
110 development process (Chapter 2) are compared to the No Action Alternative.

111 The analysis considers the following factors to determine whether effects are negligible, minor,
112 moderate, or major:

- 113 • **Context:** The geographic scope of the effect or size of the population affected, for example
114 whether effects are localized to a project site or would occur broadly across the region.
- 115 • **Intensity:** Relative magnitude of the effect as compared with the No Action Alternative.

- 116 • **Duration:** Persistence of the effect over time. The analysis considers whether effects are
117 short term (such as those limited to a construction period) or long term.

118 **3.1.1 Assumptions**

119 The effects analysis of each resource is based on best available existing information including,
120 but not limited to, the following: quantitative modeling, studies, and reports relevant to the
121 project area, and co-lead agency expertise.

122 Estimated condition under the No Action Alternative and MO conditions is based on
123 extrapolation of current trends and consistent with current laws, regulation, and policies.

124 For purposes of comparing MOs and developing preliminary costs, the EIS assumes that (1)
125 operations under the MOs, including the measures in MO3 that include lower Snake River
126 projects embankment breach, would be initiated at the signing of the RODs and (2) the
127 construction period for these structural measures would occur over 2 consecutive years.

128 The analysis considers the following assumptions for implementation of dam breach:

- 129 • Lower Granite and Little Goose Dams would be breached in year 1, followed by Lower
130 Monumental and Ice Harbor Dams in year 2.
- 131 • Drawdown rate of 2 feet per day maximum evacuation rate for safety purposes and to
132 prevent damage to infrastructure adjacent to each reservoir.
- 133 • Construction (demolition) to begin in August (low water) and last through January to reduce
134 safety risks and minimize impacts to ESA-listed fish.
- 135 • Embankment excavation duration ranges from 28 to 60 days, depending upon site
136 conditions at each location.
- 137 • Modifications at the dams could begin prior to start of excavation.

138 Given the uncertainty over if, or when, Congress might authorize dam breach in MO3, these
139 assumptions were necessary to establish a reference condition to evaluate the likely effects of
140 MO3.

141 **3.1.2 Resources Screened from Further Analysis**

142 Consistent with 40 C.F.R. § 15017(a)(3), land use was screened from further analysis because it
143 was not identified as a significant issue during the scoping process, was not anticipated to have
144 adverse or beneficial changes with implementation of any MO, and thus was not analyzed as a
145 stand-alone resource. Where direct and indirect land-use impacts surfaced during the analysis
146 of impacts to other resources, such as for water supply (Section 3.12), potential changes in land
147 use are described in that section.

148 **3.1.3 Summary of Environmental Consequences**

149 Table 3-1 summarizes the expected effects on resources analyzed for each of the MOs, as
150 compared to the No Action Alternative. The remainder of this section discusses the evaluations
151 that resulted in these expectations.

152 **Table 3-1. Summary of Expected Effects by Multiple Objective Alternative**

Resource	NAA	MO1	MO2	MO3	MO4
Hydrology and Hydraulics	Same or similar to affected environment. All CRS projects are modeled to represent the current 2016 operating rules and constraints.	<p>Moderate changes in reservoir levels can occur seasonally at Libby, Hungry Horse, Grand Coulee, and Dworshak Dams, with major differences from the NAA occurring in some high and low forecast years. The largest changes typically occur in winter and spring months, with the exception of at Dworshak Dam where the changes occur in the summer. Minor changes in operating levels occur at the four lower Snake River projects and the four lower Columbia River projects. There are no changes in minimum and maximum reservoir levels at any of the reservoirs.</p> <p>Moderate changes in river flow can occur on the Kootenai River downstream of Libby Dam in the winter and early spring, and minor changes occur on the Flathead River below Hungry Horse Dam in the winter, early spring, and late summer. Moderate to major flow changes can occur immediately downstream of Dworshak Dam and on the Clearwater River in August and September, leading to minor to moderate changes through the lower Snake River and negligible to minor changes through the lower Columbia River. Changes to seasonal storage result in relatively large flow changes below Grand Coulee Dam, but the percent change in total flow is negligible to moderate.</p>	<p>Moderate changes in reservoir levels occur at Libby, Hungry Horse, Grand Coulee, and Dworshak Dams, with major change occurring during some high and low forecast years at Libby and Dworshak. The largest changes typically occur in late winter through the spring months. Lower Snake dams and John Day can be operated at slightly higher pools in the spring through summer months. There are no changes in minimum and maximum reservoir levels.</p> <p>Moderate changes in river flow can occur in the Kootenai River below Libby, with a notable increase in November and December and decreases in January and May. On the Flathead River below Hungry Horse Dam and the Clearwater River below Dworshak Dam, major flow increase can occur in January followed by minor decreases in flow through the spring. These changes are diluted to minor or moderate changes in the rivers downstream (e.g., the Pend Oreille River, lower Snake River, and lower Columbia River). Minor increases in flow can occur below Grand Coulee in the winter, followed by negligible decreases in the spring and summer.</p>	<p>Moderate changes in reservoir levels occur at Libby and Hungry Horse Dams, with major change occurring during some high and low forecast years at Libby Dam. There are negligible changes to Lake Roosevelt water levels and no changes at Dworshak Dam. John Day Dam has a minor increase in water levels in the spring, otherwise no changes. There are no changes in minimum and maximum reservoir levels at any of the storage projects, but water levels in the four lower Snake River dams are dramatically lowered as the step-reservoir system is converted to a free-flowing river reach.</p> <p>Moderate changes in river flow can occur in the Kootenai River below Libby, with notable increase in November and December and decreases in January and May. Minor changes in flow occur on the Flathead River below Hungry Horse Dam in the winter, early spring, and late summer. Below Grand Coulee Dam, there are minor increases in November and December river flow, and minor decreases later in the year, particularly in dry years. These translate to very minor to negligible decreases further downstream below McNary Dam.</p> <p>On the lower Snake River, changes to flow amounts would be minor since the four lower Snake River dams are run-of-river projects, not storage projects. However, without the reservoirs, the water particle travel time through the reach could be reduced by an order of magnitude.</p>	<p>Moderate changes in reservoir levels can occur seasonally at Libby, Hungry Horse, and Grand Coulee Dams, in high and low forecast years. Major changes are in the summer during low water years at Grand Coulee, Hungry Horse, Albeni Falls, and Libby Dams to support McNary Dam augmentation. Minor changes occur in the lower Snake River projects and the four lower Columbia River dams, respectively, in the spring-summer months.</p> <p>Moderate changes in river flow can occur in the Kootenai River in the winter and spring months. Minor changes in flow occur on the Flathead River below Hungry Horse Dam in the winter, early spring, and late summer. In low water years, moderate flow changes occur below Libby and Hungry Horse Dams in the summer, and at Albeni Falls Dam in June and September. Below Grand Coulee Dam, flow changes are typically negligible but minor changes are common in lower flow years. Minor flow changes can occur through the lower Columbia River in lower water years, especially in May through July.</p>

Resource	NAA	MO1	MO2	MO3	MO4
River Mechanics	Negligible change	<p>Minor change in depositional patterns with temporary head-of-reservoir deposits shifting downstream into Lake Roosevelt, although available deposit volume is limited.</p> <p>Minor decrease in the amount of sediment passing the Clearwater River at the confluence of the Snake and Clearwater Rivers.</p> <p>Minor amount of coarsening of bed sediment at the head of Lake Roosevelt.</p> <p>Minor (less than 1% change) in average annual volume of sediment depositing in the Snake River FNC and LCR FNC.</p> <p>For the other metrics, the effects would be negligible.</p>	<p>Minor change in depositional patterns with temporary head-of-reservoir deposits shifting downstream into Dworshak Reservoir.</p> <p>Minor amount of coarsening of bed sediment at the head of Lake Roosevelt.</p> <p>Minor (less than 1% change) in average annual volume of sediment depositing in the Snake River FNC and LCR FNC.</p> <p>For the other metrics, the effects would be negligible.</p>	<p>Due to the Breach Snake Embankments measure, four run-of-river reservoirs would be drawn down and converted to a riverine environment. The current reservoirs contain fine sediment deposits that would partially erode leaving margin sediment on high terraces behind. The new river bottom after breaching would initially become finer and gradually coarsen over the long term. The change in the overall geomorphic character would occur on the Snake and Clearwater Rivers within the backwater extents of Lower Granite Reservoir downstream to the confluence with the Columbia River.</p> <p>Potential for a major increase in the amount of sediment passing downstream of the Snake River into the Columbia River above McNary.</p> <p>Potential for major increase in amount of material depositing in McNary Reservoir.</p> <p>Dredging would stop in the lower Snake River. Minor increase in average annual volume of sediment passing into the lower Columbia below McNary.</p> <p>Effects at the remaining storage project would be negligible.</p>	<p>Minor change in depositional patterns in the Columbia River and Spokane River entering Lake Roosevelt. Minor change in head of reservoir sediment mobilization with deposits becoming coarser in John Day Reservoir.</p> <p>Minor change in shoreline exposure at Hungry Horse Reservoir. Minor amount of bed sediment coarsening in Lake Roosevelt and reaches upstream to the U.S.-Canada border. Minor amount of bed sediment coarsening in Snake River downstream of Ice Harbor Dam. Minor amount of bed sediment coarsening in Columbia River from the Snake River confluence to Wallula, Washington.</p> <p>Minor amount of bed sediment coarsening in Columbia River at the upstream end of John Day Pool. Minor amount of coarsening in Columbia River between John Day Dam and Skamania, Washington.</p> <p>Minor amount of coarsening of bed sediment at the head of Lake Roosevelt. Minor (less than 1% change) in average annual volume of sediment depositing in the Snake River navigation Channel and LCR FNC.</p>

Resource	NAA	MO1	MO2	MO3	MO4
Water Quality	Same or similar to affected environment.	Minor increase in spill and associated TDG levels at Libby Dam due to the project's draft and refill operations. Overall negligible water quality effects in Regions A, B, and D, with the exception of major reductions in TDG below Grand Coulee Dam in Region B. In Region C, moderate adverse effects to water temperature and negligible effects to TDG and other water quality parameters would occur.	In Region A, negligible to minor improvements to water quality would occur. In Region B, negligible water quality effects would occur, with the exception of major reductions in TDG below Grand Coulee Dam. In Regions C and D, negligible effect to water temperatures would occur. In Regions C and D, frequency of exceeding state TDG water quality standards would decrease.	Overall minor effect on water quality in Region A. Negligible to minor overall water quality effect in Region B, with the exception of major reductions in TDG below Grand Coulee Dam. Major short-term adverse effect on water quality due to the mobilization of sediment during dam breaching. Long-term beneficial effect on water quality in Region C, including major reductions in TDG and spring and fall water temperatures, while there would be warmer water temperatures in the summer. Moderate short-term adverse effect on water quality, particularly in McNary Reservoir due to the mobilization of sediment during dam breaching. Long-term negligible to minor beneficial effect on water quality in Region D.	Negligible to minor adverse water quality effects in Regions A and B, with the exception of major reductions in TDG below Grand Coulee Dam. Negligible to major increase in TDG levels in Regions C and D, depending on project. Minor to negligible effects to water temperature in Regions C and D.
Anadromous Fish	Same or similar to affected environment	Models predict that returns of salmon and steelhead would be similar to the NAA or higher. Elevated temperatures during summer months would have a negligible to minor adverse effect on Snake River sockeye, fall Chinook and steelhead. In addition, MO1 could have minor adverse effects to chum, and minor beneficial effects for lamprey. These effects on anadromous fish are generally expected to be beneficial with negligible to minor changes as compared to the NAA.	Lower spill would, generally, increase travel time, transportation, and the number of powerhouse encounters for juvenile outmigrants. Modeled species show two separate results. CSS modeling predicts major decreases in survival and adult returns, and major increases in travel time, and powerhouse passage, which would lead to major adverse effects relative to the NAA. By contrast, NOAA modeling predicts minor decreases in survival, and minor increases in travel time and powerhouse passage, but increases in transport result in minor increases in adult returns. Minor beneficial effects for lamprey. These modeled changes under MO2 range from minor beneficial effects to a major adverse effect depending on species and latent mortality assumptions.	In general, anadromous species not migrating to or from the Snake River may see minor changes in passage through the lower Columbia River, while effects to Snake River anadromous species are expected to be a major beneficial effect after short-term major adverse effects associated with dam removal stabilize. Minor beneficial effects for lamprey are expected.	The degree to which the alternative affects anadromous fish varies widely between the two models used to evaluate benefits. The CSS model predicts the potential for large increases in anadromous salmon and steelhead returns, but the Life Cycle Model predicts that unless latent mortality effects are reduced by more than 10%, the net impact to Snake River Chinook salmon is estimated to be negative. This potential negative effect is also possible for Snake River steelhead based on recent observations of beneficial effects of transport. Snake River sockeye may benefit from reduced levels of transport. Minor beneficial effects for lamprey are expected. Overall, predicted effects from this MO range from moderately negative to major beneficial effect and also vary widely by species.
Resident Fish	Same or similar to affected environment.	While MO1 results in both beneficial and adverse effects on resident fish, overall, these effects are expected to be negligible, minor, or in some cases localized moderate as compared to the NAA.	MO2 has minor to major adverse effects in some localized areas due to change in water elevation and flows. Effects in the lower Columbia River would be minor.	Breaching of the lower Snake River projects would have major long-term beneficial effects to resident fish in the Snake River; however, during the breaching, major short-term adverse effects would occur. Effects outside of the Snake River would be similar to MO1.	MO4 has effects ranging from minor to major adverse for resident fish. Changes in upper Basin flow levels and reservoir elevations, particularly in low-flow years are particularly impactful. Region B would also see moderate to major effects, particularly in dry years when Lake Roosevelt would be drawn down deeper and summer outflows would increase. In Regions C and D, resident fish would be affected by increased TDG.

Resource	NAA	MO1	MO2	MO3	MO4
Vegetation, Wetlands, Wildlife, and Floodplains	Same or similar to affected environment	<p>Minor effect to wildlife, vegetation, and wetlands associated with operation of Libby Dam. and negligible effect for other areas in Region A.</p> <p>Minor adverse effect to wildlife habitat and wetland vegetation for Lake Roosevelt. Negligible effects to other areas in Region B.</p> <p>Minor (Dworshak) and negligible change (lower Snake River) to habitat, vegetation, and wildlife in Region C.</p> <p>Negligible effect to habitat, vegetation, and wildlife in Region D.</p> <p>Negligible effects on floodplains in Regions B and C, with minor effects in Region A and D below Bonneville Dam.</p> <p>For special status species, there would be negligible effects.</p>	<p>Moderate effects to Region A.</p> <p>Minor effect to vegetation, wetlands, habitat, and wildlife in Lake Roosevelt. Negligible effect in other locations in Region B.</p> <p>Negligible effects in Regions C. Minor effects in Region D.</p> <p>Minor effects on floodplains in Regions A and B. Negligible in Region C, with minor effects in Region D below Bonneville Dam.</p> <p>For special status species, there would be negligible effects.</p>	<p>Moderate adverse effect on wetlands, vegetation, habitat, and wildlife in Region A.</p> <p>Negligible effects in Region B.</p> <p>In Region C, vegetation, habitat, and wildlife along the existing shorelines would either be lost or change how wildlife utilize the area. However, new vegetation and habitat types along new shoreline would be added associated with dam breaching, resulting in negligible beneficial effects and major negative effects.</p> <p>Negligible effects in Region D.</p> <p>Negligible effects on floodplains in Regions A, B, and D, with major beneficial effects in Region C below Dworshak Dam.</p> <p>For special status species, there would be negligible effects to all except California sea lion and Steller sea lion where they may increase their activity at Bonneville and The Dalles Dam.</p>	<p>Moderate adverse effect on wetlands, vegetation, habitat, and wildlife in Region A and D.</p> <p>Minor effect in Regions B.</p> <p>Negligible effects on wildlife and habitats in Region C.</p> <p>Moderate effects on floodplains in Regions B and C, with minor effects in Region D below John Day Dam.</p> <p>For special status species, there would be negligible effects.</p>
Power Generation and Transmission	Same or similar to affected environment. Power rates may change over time if there are reductions in regional fossil fuel generation as many coal plants in the region are slated for retirement.	<p>Long-term, moderate, adverse effects on power costs and rates. Hydropower generation from the CRS projects would decrease by 130 aMW (roughly enough to power 100,000 households annually). The FCRPS, which includes the CRS would lose 290 aMW of firm power available for long-term, firm power sales to preference customers under critical water conditions. The reduction in generation would reduce power system reliability, requiring replacement power resources that could cost up to \$160 million per year. Bonneville's PPF wholesale power rates would experience upward rate pressure from 6.0% to 8.6%. (Cost uncertainties could cause upward pressure on the PF rate by up to 14%.) Regional average residential retail rates for power would experience upward rate pressure from between +0.62% and +0.74% depending on the applicable scenario, but the effect would be larger for public power customers and range up to +3.4% in some counties. These effects could be greater if fossil fuel generation is reduced under the NAA.</p>	<p>Long-term, moderate beneficial effects on system reliability.</p> <p>Hydropower generation from the CRS projects would increase by 450 aMW (roughly enough to power 360,000 households annually), and the FCRPS would gain 370 aMW of firm power available for long-term firm power sales. This would improve power system reliability and reduce electricity costs. Bonneville's PF wholesale power rates would decrease about 0.8%. (Cost could cause upward pressure on the PF rate by up to 2.7%.) Retail electricity rates would remain similar to the NAA. (If collecting fish for transport at McNary Dam were accomplished with a more cost-effective measure instead of with a powerhouse surface passage structure, Bonneville's wholesale PF rate would experience downward rate pressure by about 4% and retail rates would also experience downward pressure.) The reliability benefits of MO2 would be greater if fossil fuel generation is reduced under the NAA.</p>	<p>Long-term, major, adverse effects on power costs and rates. Hydropower generation from the CRS projects would decrease by 13%, or 1,100 aMW (roughly enough to power 900,000 households annually). The FCRPS would lose 730 MW of firm power available for long-term firm power sales. Bonneville's PF wholesale power rates would experience upward rate pressure by 10% to 19%. (Cost uncertainties could cause upward pressure on the PF rate by up to 50%.) The loss of hydropower generation at Ice Harbor would require that a transmission reinforcement project be in place prior to breaching of the dams, which would cost about \$94 million. Regional average residential retail rates for power would experience upward rate pressure between +1.6% and +3.6%, depending on the applicable scenario, but the effect would be larger for public power customers and range up to +8.1% in some counties. These effects would be greater if fossil fuel generation is reduced under the NAA.</p>	<p>Long-term, major, adverse effects on power costs and rates. Hydropower generation from the CRS projects would decrease by 16%, or 1,300 aMW (roughly enough to power 1 million households annually). The FCRPS would lose 870 MW of firm power available for long-term firm power sales. Bonneville's PF wholesale power rates would experience upward rate pressure by 15% to 25%. (Cost uncertainties could cause upward pressure on the PF rate by up to 41%.) The reduction in generation would reduce power system reliability, requiring replacement power resources that would cost up to \$580 million per year. Regional average residential retail rates for power would experience upward rate pressure between +2.8% and +3.2%, depending on the applicable scenario, but the effect would be larger for public power customers and range up to +11% in some counties. Effects could be greater if fossil fuel generation is reduced under the NAA.</p>

Resource	NAA	MO1	MO2	MO3	MO4
Air Quality and Greenhouse Gases	Air quality would most likely improve and GHG emissions be reduced over time due to current trends in decarbonization.	Negligible to potentially minor, long-term effects on air quality and GHG emissions. Effects could be adverse or beneficial depending on whether fossil fuel or renewable resources replace reduction in hydropower generation. Short-term minor adverse effects in Region D from localized construction activities.	Minor beneficial air quality and GHG emissions effects from increased hydropower generation.	Long-term, moderate, adverse effects on air quality and GHG emissions from increased fossil fuel power generation, particularly in Region D and in Montana and Wyoming, even assuming resources replacing hydropower are renewables. Minor increases in emissions in Regions C and D from increased commercial truck and rail transport to replace barges. Short-term moderate adverse effects from localized construction activities in Region C.	Long-term, moderate, adverse effects on air quality and GHG emissions from increased fossil fuel power generation, particularly in Montana and Wyoming, even assuming resources replacing hydropower are renewables. Short-term, minor, adverse effects from localized construction activities in Regions A, C, and D.
Flood Risk Management	Same or similar to affected environment	No increases in flood risk are anticipated as a result of MO1. Minor decreases in flood risk are possible in some areas, especially due to winter events in Region D.	No increases in flood risk are anticipated as a result of MO2. Minor decreases in flood risk are possible in some areas, especially due to winter events in Region D.	No increases in flood risk are anticipated as a result of MO3. Under MO3, the draining of Lower Granite Reservoir and breaching of the lower Snake River dams would result in no anticipated change in flood risk.	Minor to negligible changes in flood risk are anticipated as a result of MO4. Minor decreases in flood risk are possible in some areas, especially due to winter events in Region D.
Navigation and Transportation	Same or similar to affected environment	MO1 would result in negligible increases in average annual costs for deep draft navigation and shallow draft navigation. Negligible effects to the cruise line industry. Moderate effects would occur to the Inchelium-Gifford Ferry at Lake Roosevelt in wet years.	MO2 would result in negligible increases in average annual costs for deep draft navigation and a minor decrease in costs for shallow draft navigation. Negligible effects to the cruise line industry. Moderate effects would occur to the Inchelium-Gifford Ferry at Lake Roosevelt in wet years.	MO3 would result in major adverse effects related to elimination of commercial navigation on the lower Snake River. Costs of shipping would increase 10% to 33% on average region-wide. Investments in infrastructure may be required. Cruise ship transit to the lower Snake River would not be possible. Additional dredging would be required in the McNary pool to access port facilities for 2 to 7 years. Reductions in regional economic benefits to port cities where cruise line expenditures would have occurred; redistribution of regional demands for material handlers. Adverse effects to accident rates; increased highway traffic and congestion. Minor effects would occur to the Inchelium-Gifford Ferry at Lake Roosevelt in wet years.	MO4 would result in minor increases in average annual costs for deep draft navigation and minor decreases in average annual costs for shallow draft navigation. Negligible effects to the cruise line industry. Moderate effects would occur to the Inchelium-Gifford Ferry in wet years.
Recreation	Same or similar to affected environment	Negligible to minor effects on water-based recreation with the exception of localized, moderate adverse effects to recreation fishing along the Clearwater River in August and September. Overall, however, effects to quality of recreation experience related to fishing, hunting, wildlife viewing, swimming, and water sports at river recreation sites would be negligible.	Negligible to minor effects on water-based recreation. Adverse short- and long-term effects of MO2 on recreation would be minor. Minor adverse effects to quality of recreation experience for fishing, hunting, wildlife viewing, swimming, and water sports associated with changing river conditions in river segments below reservoirs.	Negligible to minor effects to water-based recreation visitation and quality in Region A, B, and most of C. Major adverse effects to water-based recreation at the four lower Snake River projects in Region D, as well as water-based recreation on left bank of Lake Wallula (Region C). Some of the adverse effects to reservoir recreation may be replaced to some extent over time, by increased river recreation activities, higher quality recreational experience for fishing, hunting, wildlife viewing, and river-based recreation activities.	Minor to major localized adverse effects to water-based recreation. At Lake Roosevelt minor effects are expected during a typical year, and major localized water-based recreation access effects during dry water year. Major adverse effects could occur in low water years at Lake Pend Oreille due to accessibility issues at private docks and marinas. Changes in the quality of recreational experience are anticipated to be potentially adverse as well as beneficial.
Water Supply	Same or similar to affected environment	MO1 does not have any measures that would affect the ability to deliver water to meet current water supply.	MO2 does not have any measures that would affect the ability to deliver water to meet current water supply.	Measures implemented under MO3 could affect delivery of current water supply in Region C, and are expected to result in major effects. Measures implemented under MO3 are expected to have minor effects in Region D.	Overall, MO4 is expected to result in minor effects to water supply in Region D.

Resource	NAA	MO1	MO2	MO3	MO4
Visual	Short-term minor and moderate visual quality effects associated with operational measures. The effects to the casual observer would be minimal; however, sensitive viewers would experience moderate effects. Impacts from structural measures would have a minor effect.	The operational measures under MO1 would have a similar effect as the NAA. There would be a moderate effect to visual quality from new fish passage structures and minor effect from modifications of existing structures in Region D and the lower Snake River projects in Region C.	Same as MO1.	Operational measures would have a similar effect on the view shed and to viewers as the NAA. Modifications to lower Snake River projects would result in a major visual quality effect. Effects to viewers depend on their perspective of these changes, which would be either beneficial or adverse.	The operational measures under MO4 would have a major effect on Lake Koocanusa, Hungry Horse Reservoir, Lake Pend Oreille, and Lake Roosevelt. For all other reservoirs, the visual quality effect, and effect to all viewer groups would be similar to NAA. Structural measures would have the same effect as MO1
Noise	Same or similar to affected environment	Negligible to minor noise effects from structural and operational measures.	Same as MO1.	In Regions A, B, and D, noise effects would be similar to those in MO1. In Region C, breaching of the dams would result in temporary moderate noise effects from construction activities.	Negligible to minor noise effects from structural and operational measures.
Cultural Resources	Same or similar to affected environment	Ongoing major effects to cultural resources and tribal interests. Additional major effects to cultural resources at Hungry Horse, Lake Roosevelt, and Dworshak reservoirs. There is the potential for major effects to the sacred site, Kettle Falls, if changes in reservoir elevations result in increased looting.	Ongoing major effects to cultural resources and tribal interests. Additional major effects to cultural resources at Dworshak and Lake Roosevelt. There is the potential for major effects to the sacred site, Kettle Falls, if changes in reservoir elevations result in increased looting.	Ongoing major effects to cultural resources and tribal interests. Potential for additional major adverse effects to cultural resources compared to the NAA in the lower Snake River due to potential exposure of 14,000 acres currently inundated. The exposure of the traditional cultural properties would allow for some traditional uses that have not been possible since the dams were built. There is also the potential for additional major adverse effects to cultural resources at Hungry Horse Reservoir.	Ongoing major effects to cultural resources and tribal interests. Additional major effects to cultural resources at Lake Roosevelt, John Day, and Hungry Horse. Additional moderate effects at the remaining lower Columbia River projects due to additional drawdown. There is the potential for major effects to Kettle Falls (sacred sites) if changes in reservoir elevations cause increased looting. Changes in reservoir elevation at Albeni Falls may result in a decrease of access to Bear Paw Rock, which may result in less tribal visitation or access to the site.
Indian Trust Assets, Tribal Perspectives, and Tribal Interests	Same or similar to affected environment	Negligible to minor beneficial effects to tribal interests and resources (anadromous and resident fish) with some localized minor to moderate negative effects to resident fish. No direct or indirect effects to ITAs.	Minor to major negative effects to tribal interests and resources, especially anadromous fish and associated harvest rights. No direct or indirect effects to ITAs.	Major beneficial effects to tribal interests and resources for lower river and Snake River Basin tribes. Dam breaching and restoring free flowing sections of river is discussed favorably in many tribal perspectives submittals. Negligible to minor effects for upper basin tribal interests and resources. No direct or indirect effects to ITAs.	Uncertain effects to key tribal interests and resources, specifically anadromous fish, and moderate to major adverse effects to upper basin tribal resources such as resident fish, wildlife, wetlands, and vegetation. No direct or indirect effects to ITAs.

Resource	NAA	MO1	MO2	MO3	MO4
Environmental Justice	Same or similar to affected environment	Through analysis considering effects detailed in Chapter 3, Affected Environment and Environmental Consequences; Chapter 4, Climate; Chapter 5, Mitigation; and Chapter 6, Cumulative Effects, there would not likely be a disproportionately high and adverse effect on environmental justice populations for MO1.	Through analysis considering effects detailed in Chapter 3, Affected Environment and Environmental Consequences; Chapter 4, Climate; Chapter 5, Mitigation; and Chapter 6, Cumulative Effects, there would not likely be a disproportionately high and adverse effect on environmental justice populations for MO2.	Through analysis considering effects detailed in Chapter 3, Affected Environment and Environmental Consequences; Chapter 4, Climate; Chapter 5, Mitigation; and Chapter 6, Cumulative Effects there would not likely be a disproportionately high and adverse effect on environmental justice populations for MO3.	Through analysis considering effects detailed in Chapter 3, Affected Environment and Environmental Consequences; Chapter 4, Climate; Chapter 5, Mitigation; and Chapter 6, Cumulative Effects there, would not likely be a disproportionately high and adverse effect on environmental justice populations for MO4.
Total Annual-Equivalent Costs for the Alternatives (2019 \$)	\$1,055 million	\$1,076 million	Low estimate = \$1,108 million High estimate = \$1,161 million	Low estimate = \$897 million High estimate = \$1,002 million	Low estimate = \$1,000 million High estimate = \$1,105 million

153 Note: aMW = average megawatt; Bonneville = Bonneville Power Administration; CRS = Columbia River System; FCRPS = Federal Columbia River Power System; FNC = Federal navigation channel; GHG = greenhouse gas; ITA = Indian Trust Asset; LCR FNC = Lower
154 Columbia River Federal Navigation Channel; MO1, 2, 3, 4 = Multiple Objective Alternative 1, 2, 3, 4; NAA = No Action Alternative; NOAA = National Oceanic and Atmospheric Administration; PF = Priority Firm; TDG = total dissolved gas.

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156 **3.2 HYDROLOGY AND HYDRAULICS**

157 **3.2.1 Introduction and Background**

158 The term hydrology and hydraulics (H&H) is commonly used in a general manner to discuss the
159 quantity, movement, or behavior of water. The hydrologic and hydraulic characteristics
160 discussed in this H&H Affected Environment and Environmental Consequences sections relate
161 to surface water conditions: flow rates in rivers, and water levels in reservoirs and rivers.

162 The section describes the climate of the CRS, the characteristics of the river system organized in
163 four separate regions, how reservoirs in the CRS are operated together, and water level
164 characteristics on a reach-by-reach basis.

165 **3.2.1.1 Columbia River Basin Description**

166 The Columbia River drains approximately 258,000 square miles. The drainage area comprises
167 most of Washington, Oregon, and Idaho; the western quarter of Montana; the southeastern
168 corner of British Columbia; and small portions of Wyoming, Nevada, and Utah. Although only
169 15 percent of the river's basin lies in Canada, 38 percent of the average annual flow volume (as
170 measured at The Dalles, Oregon) originates in Canada. In addition, up to 50 percent of the peak
171 flood waters in the lower Columbia River between Oregon and Washington originate in Canada
172 and result from snowmelt in the upper Columbia River Basin. Its average annual runoff is 198
173 million acre-feet (Maf), as measured at the river's mouth.

174 The Columbia River originates in British Columbia, Canada, and flows 1,204 miles through
175 Canada and the United States to the Pacific Ocean (456 miles in British Columbia and 748 miles
176 in the United States)¹ (Figure 3-1). The river begins in Columbia Lake on the west slope of the
177 Rocky Mountain Range in British Columbia and enters the United States in the northeastern
178 corner of the state of Washington. The river then flows south and west, then southeasterly to
179 its confluence with the Snake River near Richland, Washington. It turns westward for 320 miles,
180 forming the Washington-Oregon border before flowing into the Pacific Ocean near Astoria,
181 Oregon. Its largest tributary, the Snake River, travels 1,038 miles from its source in Yellowstone
182 National Park in Wyoming before joining the Columbia River.

183 Major tributaries of the Columbia River include the following:

- 184 • The Kootenai River, which originates in British Columbia, Canada, and flows through
185 Montana and Idaho before joining the Columbia River in British Columbia.
- 186 • The Flathead River, which originates in British Columbia and Montana and flows through
187 Montana, draining into the Clark Fork River, which flows into Lake Pend Oreille.
- 188 • The Pend Oreille River, which originates at the outlet of Lake Pend Oreille and flows through
189 Idaho and Washington before joining the Columbia River in British Columbia.
- 190 • The Yakima, Spokane, Okanogan, Wenatchee, and Methow Rivers in Washington.

¹ River miles and reach lengths from the Corps' Columbia River Basin modeling schematic.

- 191 • The Snake River, which originates in Wyoming and flows primarily through Idaho.
- 192 Tributaries of the Snake River include the Clearwater River and the Salmon River.
- 193 • The John Day River and Deschutes River in Oregon, which join the Columbia River upstream
- 194 of John Day Dam and The Dalles Dam, respectively.
- 195 • The Willamette River in Oregon; the MOs do not include any specific actions that would
- 196 require the Willamette projects (in most subsequent cases in this chapter, “project” is used
- 197 to collectively refer to a dam and its associated reservoir) to operate outside their normal
- 198 ranges.



199
200 **Figure 3-1. Columbia River Basin**

201 Note: Many dams besides the 14 CRS projects are shown here to illustrate the complex system of dams in the
202 Columbia River Basin.

203 Where the river meets the coast, saltwater intrusion from the Pacific Ocean extends
204 approximately 23 river miles upstream from the mouth; tidal effects can be experienced on the
205 Columbia River up to Bonneville Dam, located 146 river miles inland.

206 **3.2.1.2 Columbia River Basin Climate**

207 The climate in the Columbia River Basin ranges from a moist, mild maritime condition near the
208 mouth of the river to a relatively cool desert climate in some of the inland valleys of eastern
209 Oregon and southern Idaho. The Columbia River Basin is influenced by a modified west coast
210 marine and continental climate, which varies with elevation and proximity to mountain ranges.

211 In the mountainous regions, most of the precipitation falls during the late fall and winter
212 months, though there can also be wet springs and early summers as heavy rains and
213 occasionally severe thunderstorms affect the region. The headwaters of the Columbia River and
214 its major tributaries are in high-elevation and snow-dominant watersheds. Snow-dominant
215 watersheds are sufficiently cold in the winter to allow for precipitation to fall in the form of
216 snow and for that snow to accumulate and remain until temperatures rise in the spring and
217 summer. High-elevation summers tend to be short and cool, while the lower-elevation interior
218 regions are subject to greater temperature variability.

219 The north-south Cascade Range, the Blue and Willowa Mountains of northeast Oregon, and the
220 Rocky Mountains at the eastern and northern boundaries of the basin strongly influence climate
221 in the Columbia River Basin. The basin has dramatic elevation changes ranging from sea level to
222 more than 10,000 feet in the high mountains. The Cascade Range separates the coast from the
223 interior of the basin and has a strong influence on the climate of both areas. The basin is
224 generally cooler and wetter on the western side of the Cascades and warmer and drier to the
225 east toward the Rocky Mountains. The two important runoff patterns in the basin are the
226 snowmelt runoff in the interior east of the Cascade Range and the rainfall runoff of the coastal
227 drainages west of the Cascades. Marine influences are strongest during the winter and cause
228 most of the winter snowfall when warm moist air from the Pacific Ocean is cooled as it is forced
229 to ascend over mountainous terrain in the upper basin or when there is frontal contact with
230 Arctic air masses.

231 Most of the annual precipitation in the basin occurs in the fall through early spring, with the
232 largest share falling as snow in the mountains. This moisture, stored during the winter as
233 snowpack, is released as snowmelt in the spring and early summer. Stream flow in the
234 Columbia River typically begins to rise in mid-April, reaching a peak flow during May or early
235 June. About 60 percent of the natural runoff in the basin occurs during May, June, and July. The
236 Columbia River has an average annual runoff volume at its mouth of about 198 Maf and an
237 average annual flow of 273,500 cubic feet per second (cfs).

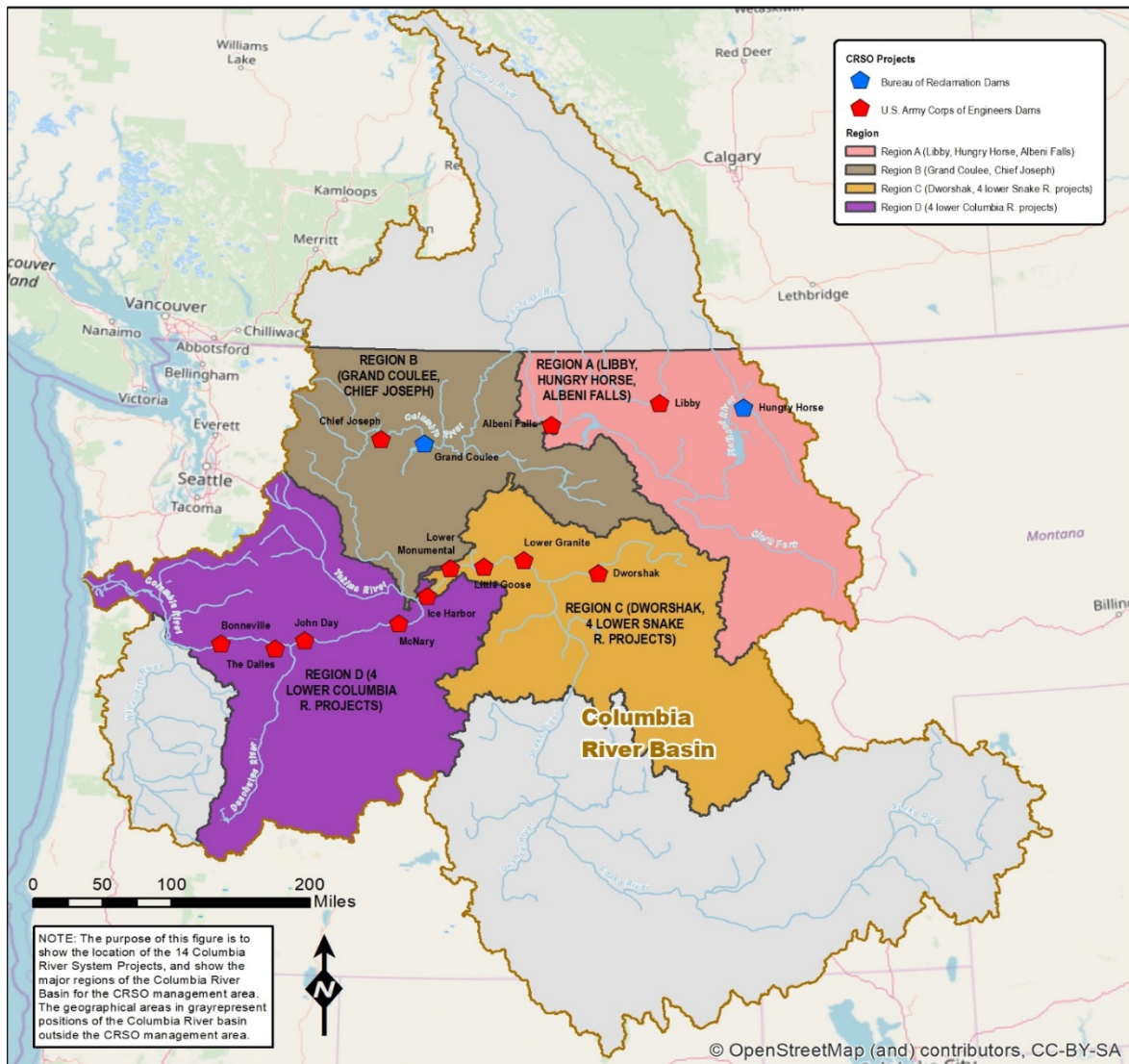
238 Chapter 4 provides an overview of projected changes in future regional climate and assesses
239 how these projected changes may impact resources and the effectiveness of the MOs. Refer to
240 Section 4.1.2 for projected changes in climate compared to the historical period for the
241 Columbia River Basin including air temperature, precipitation, snowpack, and streamflow.

242 **3.2.2 Area of Analysis**

243 The area considered in this hydrology and hydraulics evaluation is the CRS reservoirs and the
 244 river reaches downstream. The modeling of the system for this analysis is described in the H&H
 245 Appendix (Appendix B) and the Hydroregulation Appendix (Appendix I). The order of discussion
 246 goes from upstream locations to downstream locations, and is organized by the physiographic
 247 NEPA regions shown in Figure 3-2.

248 **3.2.2.1 Columbia River Basin Region Descriptions**

249 The CRS consists of subbasins, each having distinct topographic, meteorological, and/or
 250 hydrologic characteristics. These subbasins are grouped into four regions, Regions A to D, that
 251 are referred to throughout this EIS. The 14 Federal projects in the CRS and their locations are
 252 shown in Figure 3-2.



253 **Figure 3-2. Columbia River Basin Regions (Regions A, B, C, and D)**
 254

255 **REGION A**

256 This region includes the portions of the Kootenai and Pend Oreille River Systems that are within
257 the United States. The majority of the Kootenai River System and the Pend Oreille River System
258 region is mountainous, with the Continental Divide forming much of the eastern boundary; the
259 Selkirk Mountains, the north and western boundary; and the Selway-Bitterroot Mountains, the
260 southern boundary. The Cabinet and Purcell Mountains are located in the region. The elevation
261 ranges over 9,000 feet between the mountain peaks and the valley floors scattered throughout
262 the region.

263 The Kootenai(y) River System is an international system that begins in the Rocky Mountains in
264 British Columbia. From the headwaters, the river flows 173 miles to the U.S.-Canada border,
265 where it flows another 163 miles through Montana and Idaho and loops back to the
266 U.S.-Canada border. From the U.S.-Canada border, the Kootenay River (Canadian spelling) flows
267 another 105 miles in Canada before entering the Columbia River near Castlegar, British
268 Columbia. The Kootenai(y) River has five major tributaries, including the Fisher and Yaak Rivers
269 in the United States; Goat and Duncan Rivers in British Columbia; and the Moyie River, which
270 begins in Canada and enters the Kootenai River near Moyie Springs, Idaho.

271 The following dams are located within the Kootenai River System: Libby, on the Kootenai River
272 in Montana; Goat on the Goat River in British Columbia; Kootenay Canal Plant, Corra Linn,
273 Upper Bonnington, Lower Bonnington, Slocan, and Brilliant on the Kootenay River in British
274 Columbia; and Duncan Dam on the Duncan River in British Columbia.

275 The Pend Oreille River System includes over 1,000 miles of river among the North Fork, Middle
276 Fork, South Fork, and mainstem Flathead Rivers, as well as the Clark Fork, Thompson, Pend
277 Oreille, and Priest Rivers. The North, Middle, and South Fork Flathead Rivers join to form the
278 Flathead River, which flows into the Clark Fork River after passing through Flathead Lake.
279 Flathead Lake is a natural lake, but its elevation is mainly controlled by Seli'š Ksanka Qlispe'
280 (SKQ; formerly known as Kerr) Dam. The Clark Fork River is joined by Thompson River before
281 flowing into Lake Pend Oreille, which flows into the Pend Oreille River. The Pend Oreille River is
282 joined by the Priest River and then turns north, flows into British Columbia where it is called the
283 Pend-d'Oreille (Canadian spelling), and empties into the Columbia River.

284 There are nine dams in the Pend Oreille River System in the United States: Hungry Horse, on the
285 South Fork Flathead River; SKQ Dam on the Flathead River; Thompson Falls, Noxon Rapids, and
286 Cabinet George on the Clark Fork River; Priest Lake on Priest River; and Albeni Falls, Box
287 Canyon, and Boundary on the Pend Oreille River. On the Pend-d'Oreille River in Canada, there
288 are two: Waneta and Seven Mile.

289 There are three CRS dams in Region A: Libby Dam, Hungry Horse Dam, and Albeni Falls Dam.

290 **REGION B**

291 Region B includes the Spokane River System and the middle Columbia River in the United
292 States. The region is bounded on the north and west by the Cascade Range and borders the

293 Pend Oreille basin on the east; the Columbia River Plateau dominates the southern landscape in
294 the region. The highest point in the region is in the Cascade Range at approximately 9,500 feet,
295 and the lowest elevation occurs along the Columbia River near Priest Rapids Dam at
296 approximately 400 feet.

297 The Spokane River System includes the Spokane (140 river miles), St. Joe (44 river miles), and
298 Coeur d'Alene (33 river miles) Rivers. The St. Joe and Coeur d'Alene Rivers flow into Lake Coeur
299 d'Alene, located in northern Idaho, and outflow from the lake forms the Spokane River. Lake
300 Coeur d'Alene is a natural lake, but its elevation is mainly controlled by Post Falls Dam, which is
301 located approximately 8.5 miles downstream from the lake's outlet. There are six dams on the
302 Spokane River below Lake Coeur d'Alene: Post Falls, Upper Falls, Monroe Street, Nine Mile,
303 Long Lake, and Little Falls Dams.

304 The middle Columbia River has seven major tributaries: the Wenatchee, Chelan, Methow,
305 Okanogan, Sanpoil, Spokane, and Kettle Rivers. There is a diversion from the Columbia River
306 into Banks Lake in this region. Several non-Federal dams are in Region B. On the Columbia River
307 these dams are Priest Rapids Dam, Wanapum Dam, Rock Island Dam, Rocky Reach Dam, and
308 Wells Dam.

309 There are two CRS dams in Region B: Grand Coulee Dam and Chief Joseph Dam.

310 **REGION C**

311 Region C begins just downstream of Ice Harbor Dam, located approximately 9 miles upstream
312 from the confluence of the Snake and Columbia Rivers, and continues upstream along the
313 Snake River to Hells Canyon Dam, located along the Idaho-Oregon border. The region includes
314 the Clearwater River and its tributaries, with Dworshak Dam located on the North Fork
315 Clearwater River. The region is bounded on the east by the Idaho-Montana border, where the
316 Bitterroot and Rocky Mountains dominate the landscape, and on the southwest by the Wallowa
317 and Blue Mountains. The rolling hills and prairies of the Columbia River Plateau dominate the
318 northwest portion of the region. Region C has a mostly semi-arid or desert climate.

319 The major Snake River tributaries in Region C include the Clearwater, Grande Ronde, Imnaha,
320 and Salmon Rivers.

321 There are five CRS dams in Region C: Dworshak Dam, Lower Granite Dam, Little Goose Dam,
322 Lower Monumental Dam, and Ice Harbor Dam.

323 **REGION D**

324 Region D contains portions of the lower Columbia River Basin, with the furthest downstream
325 dam on the Columbia River being Bonneville Dam. Upstream of Bonneville Dam, the Columbia
326 River is not influenced by tides; downstream of Bonneville Dam, it is.

327 The reach of the Columbia River from Priest Rapids Dam to Bonneville Dam, most of which is in
328 Region D, is approximately 250 river miles long. The contributing drainage area to the reach is

329 approximately 38,150 square miles. The landscape is diverse, with the Cascade Range on the
330 west; the Blue, Wallowa, and Ochoco Mountains along the south and east; and the Columbia
331 River Plateau defining the middle and northern portion of the drainage area. Five major
332 tributaries join this reach: the Deschutes River, Snake River, John Day River, Umatilla River, and
333 Yakima River.

334 The reach that is tidally influenced extends from Bonneville Dam (the most downstream dam
335 on the Columbia River) to the mouth of the Columbia River, where it empties into the Pacific
336 Ocean. This reach is approximately 150 river miles long. Excluding the Willamette Region, the
337 contributing drainage area to the reach is 7,340 square miles. It is bounded by the Cascade
338 Range on the north and east, the Willamette River Valley on the south, and the Pacific Ocean
339 on the west.

340 The principal tributaries joining the Columbia River downstream of Bonneville Dam are the
341 Willamette River, Lewis River, and Cowlitz River. High flows on these three tributaries generally
342 occur during winter storms, from November to March, and account for most of the local runoff
343 below Bonneville Dam.

344 There are four CRS dams in Region D: McNary Dam, John Day Dam, The Dalles Dam, and
345 Bonneville Dam.

346 **3.2.3 Affected Environment**

347 **3.2.3.1 Reservoir System**

348 Since the 1880s, numerous dams—both Federal and non-Federal—have been authorized and
349 built in the basin for flood control, hydropower, fish and wildlife conservation, navigation,
350 recreation, irrigation, municipal and industrial water supply, and water quality.

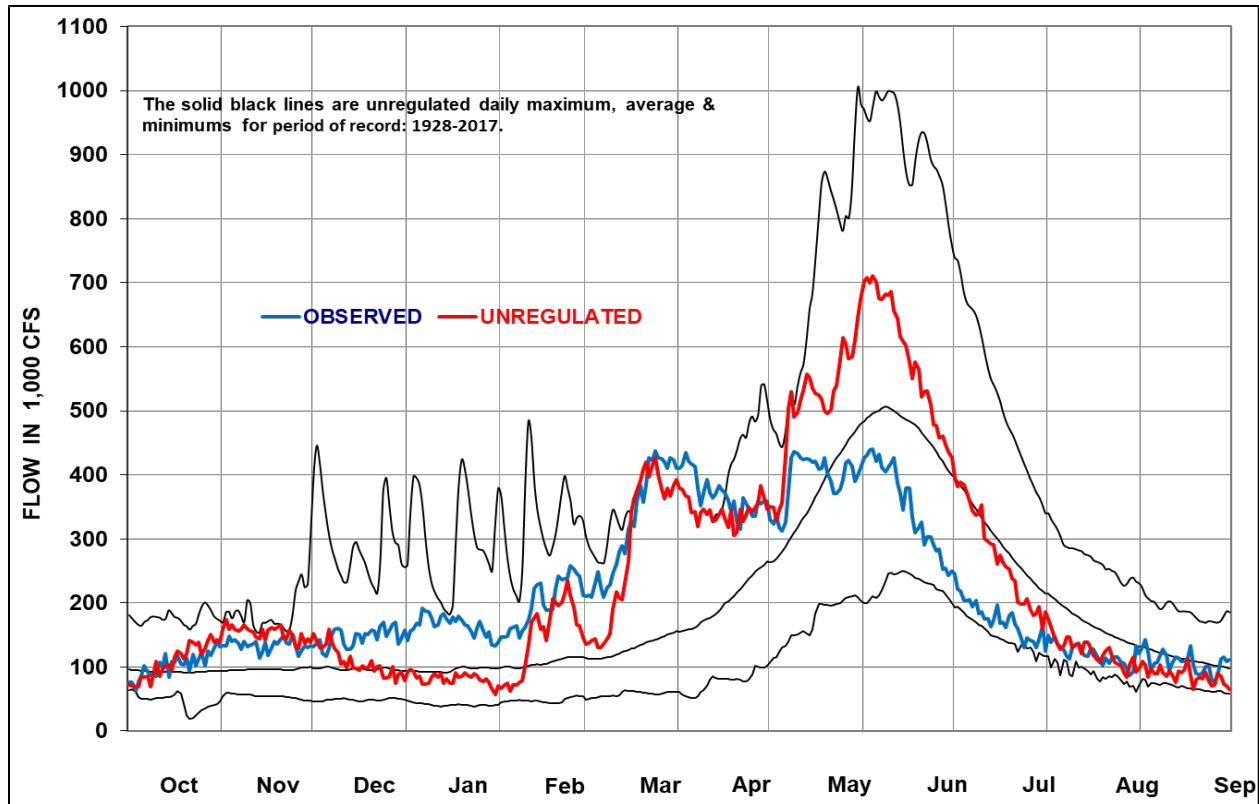
351 A figure depicting the range of flows at The Dalles is provided in Figure 3-3, with an overlay of
352 unregulated and observed (regulated) flows from water year 2017. The average annual flow
353 volume at The Dalles is 134 Maf, and the average annual flow is approximately 185,000 cfs². The
354 term “unregulated” is used to describe what the runoff in the river would be without dams³.
355 From the figure depicting the range of flows at The Dalles, an annual recurring pattern can be
356 seen, with peak flows occurring in late spring. The figure also shows that during the late spring
357 and early summer, the range of flows between the minimum and maximum lines is greater than
358 any other time of year. This means that there is more variability in natural flows in the system
359 during this time of year than at any other time. The overlay of observed flows for water year
360 2017 shows the effect of regulation by storage dams in the system. Water year 2017 had a
361 higher than average annual runoff volume of 164 Maf. Despite having a higher than average

² The most recent 30-year period is from 1981 to 2010; these averages are updated decennially and the next update will occur in 2021 for the 1991 to 2020 period.

³ Unregulated streamflow is calculated by removing the effects of reservoir regulation from observed timeseries. This systematic reconstruction of unregulated historical flow has been developed for 1928 to 2008 in the 2010 Modified Flows dataset. See the Appendix B, Part 4, *Hydrologic Data Development*, for further detail.

362 runoff volume, it is still a typical depiction of how the timing of streamflow on the Lower
363 Columbia Reach is affected by upstream storage dams.

364 The water levels behind storage dams are lowered during the winter months through early
365 spring to make room to prepare to capture high spring runoff; during this period day to day
366 reservoir discharge is also managed to support other purposes. During the winter, reservoirs
367 are also sometimes drafted to maintain minimum flow or stage requirements downstream of
368 each reservoir or in the lower Columbia River. In the late spring through early summer, flows
369 begin to increase and reservoirs are operated to manage flood risk downstream of each
370 reservoir, as well as in the lower Columbia River, and to refill. During the summer and into early
371 fall, reservoirs are drafted to provide additional flow for fish.



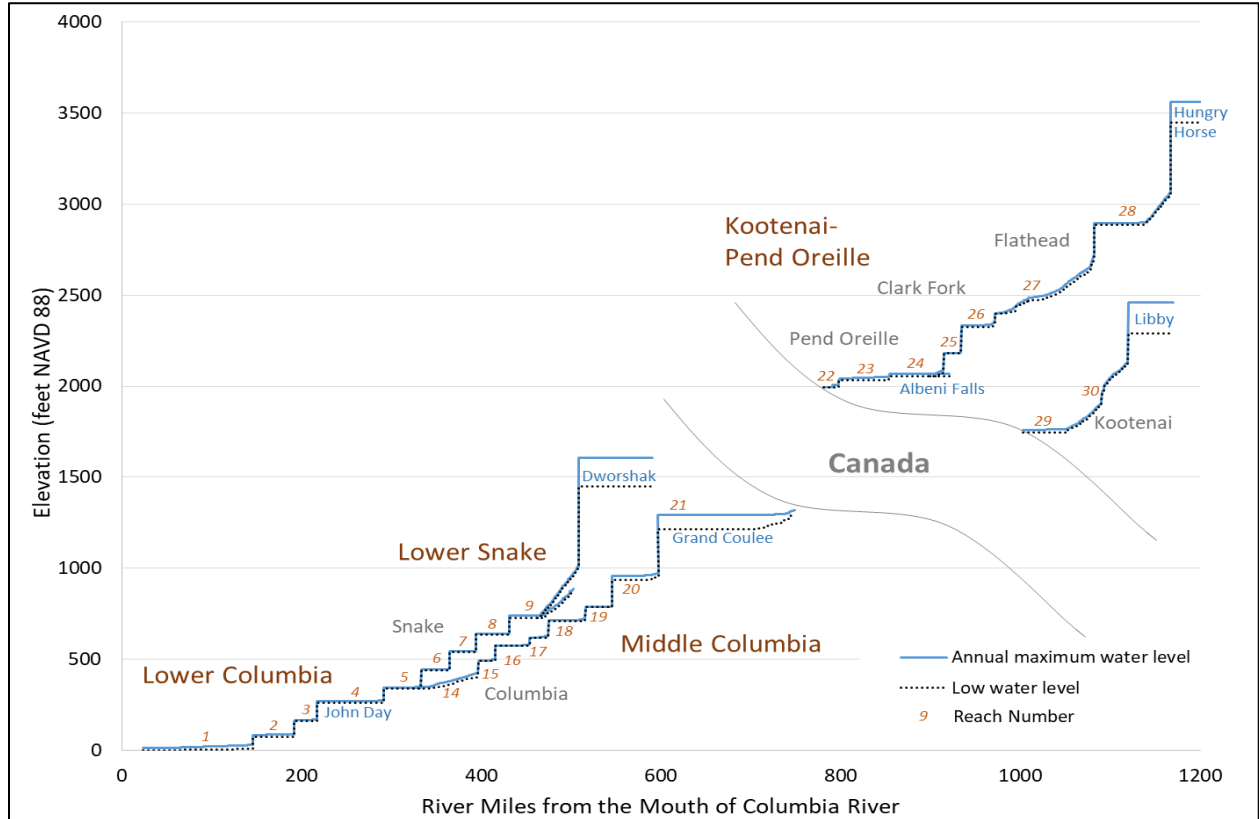
372
373 **Figure 3-3. Columbia River Stream Flows as Measured at The Dalles, Oregon, October 2016–**
374 **September 2017**

375 Note: Figure source is U.S. Entity and Canadian Entity (2017), simplified by the Corps for clarity.

376 3.2.3.2 Water Levels Between Projects

377 Water levels throughout this system are strongly influenced by the many dams, to the extent
378 that the water surface profile throughout the study area can largely be described as a series of
379 reservoirs. There are only a handful of relatively steep stretches of river that are above the
380 influence of a downstream dam and/or reservoir. Figure 3-4 shows water surface profiles for
381 most of the major rivers evaluated in this study for changes in water levels. The rivers are
382 divided into hydraulic reaches, each of which has an assigned reach number, and they are

383 shown here to introduce the reader to the numbering convention and geographic extent of
 384 each reach. Several technical teams involved with CRSO EIS environmental consequences
 385 evaluations use this reach numbering system to describe effects that would be associated with
 386 the various MOs.



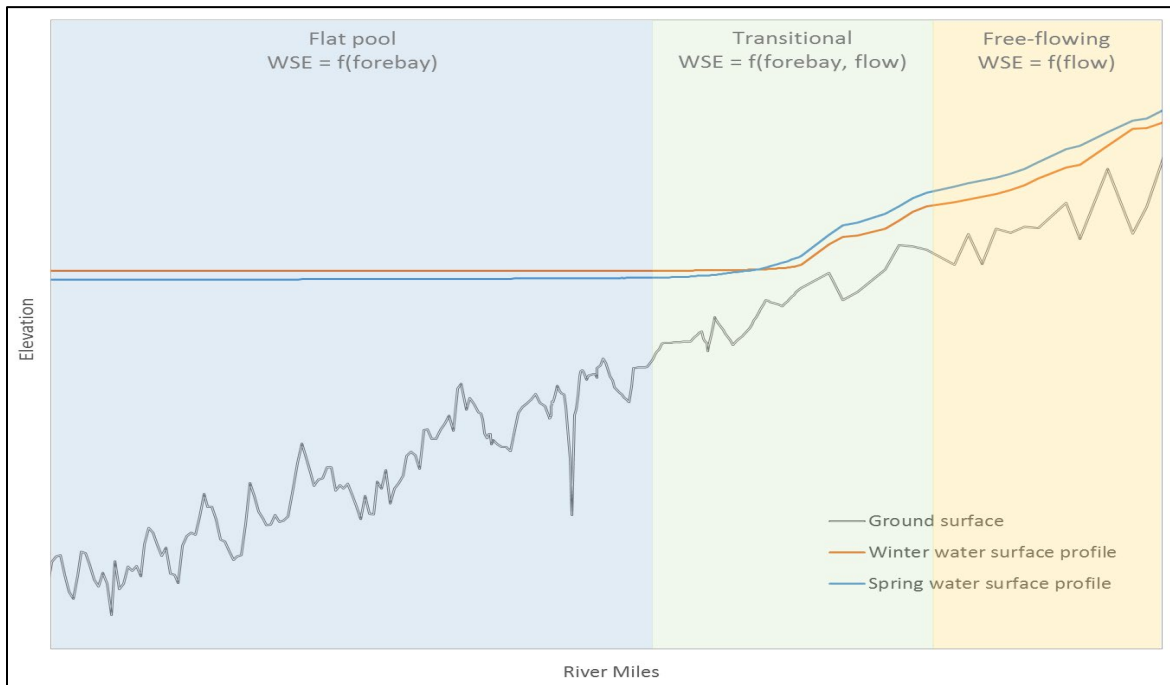
387
 388 **Figure 3-4. Water Surface Profiles for the Columbia River System Hydraulic Model Reaches**

389 Water levels at a given location will fluctuate seasonally with the hydrologic cycle, typically
 390 dominated by high flows during the spring and early summer, also called the “freshet,” and
 391 dam operations which are typically lower in the winter months and higher following the
 392 freshet. Depending on the location within a given reach, the changes in water level will be
 393 influenced by either changes in the forebay elevation held at the downstream dam, changes in
 394 the outflow from the upstream project, or a combination of the two. To facilitate discussion of
 395 impacts to water levels from changes in reservoir operations, three profile types are
 396 established: flat pool, free-flowing, and transitional. These are depicted in Figure 3-5 and
 397 described below:

- 398 • A reservoir may be considered “flat,” for practical purposes, where the water level is
 399 influenced solely by and, in most cases, is equal to the forebay elevation. The extent of the
 400 reservoir that is “flat” is related to the size of the dam, the shape and slope of the river
 401 channel, and the flow through the reach.
- 402 • The upstream portions of some reaches are considered to be “free-flowing.” In these zones,
 403 water levels are outside the influence of the downstream reservoir operations but change

404 with changes in the flowrate in the channel, which is typically dominated by outflow from
405 the upstream dam. Note, the use of the term “free-flowing” is not to be confused with
406 other interpretations related to natural or unregulated rivers.

- 407 • Most reaches will have a zone between the flat pool and free-flowing zones where the
408 water level can be influenced by both the water level held in the forebay at the
409 downstream project and the amount of flow coming into the reservoir. For this study, this
410 part of the profile is called the “transitional” zone.



411 **Figure 3-5. Water Surface and Ground Surface Profiles of Typical Hydraulic Reach, and the**
412 **Three Zones of Influence**
413

414 Each of the hydraulic reaches has a unique water surface profile. The water surface profile is
415 made from the calculated water surface at various locations throughout a reach. The water
416 surface elevation at any given location is related to the downstream boundary, such as dam
417 forebay elevations, the channel geometry (bed slope, roughness, conveyance area, etc.), and
418 the given flow condition. More detailed discussion of the H&H conditions in each reach is
419 provided in the H&H Appendix (Appendix B, Part 1, *H&H Data Analysis*), but Table 3-2
420 summarizes the key elements related to the water surface profile for each reach. Figure 3-6 is
421 provided to show the location of reaches.⁴

⁴ It should be noted that definitive boundaries of these zones for a given reach are not provided as it depends on the precision of a given analysis and metric of interest; however, general zone extents are provided to help describe the shape of a given reach’s water surface profile and where changes in flow and water level will likely impact water levels. Also, most of the apparently flat reaches are actually slightly sensitive to discharge during high flow conditions, particularly if they coincide with low pool conditions, and should therefore be considered transitional.

422 **Table 3-2. Reach-by-Reach Profile Summaries**

CRSO Region	Reach	Reach Extents	Profile Description (e.g., flat pool, free-flowing sections, constrictions)
A. Kootenai, Flathead, Clark Fork, Pend Oreille	R30 ^{1/}	Libby Dam to Crossport, Idaho Kootenai RM 157 to 219	Entire reach is free-flowing, i.e., above influence of Kootenay Lake downstream. Includes Kootenai Falls (Kootenai RM 191)
	R29	Crossport, Idaho, to U.S.-Canada Border Kootenai RM 103 to 157	Water levels influenced by Kootenay Lake, especially below Bonners Ferry, Idaho (RM 150).
	R28	Hungry Horse to SKQ Flathead RM to 79 to 158 includes Whitefish River	Reach begins at bottom of Flathead Lake (RM 79.437) above constriction above SKQ Dam. The upper end of Flathead Lake is at roughly RM 110 and the estuary extends for another 20 meandering miles upstream on the Flathead River. Free-flowing reaches exist above roughly RM 133 on the Flathead River and RM 3 on the Whitefish River.
	R27	SKQ to Thompson Falls Clark Fork RM 72 to 110 and Flathead RM 0 to 74	Thompson Falls is a run-of-river dam. Free-flowing reach along both Clark Fork and Flathead reaches.
	R26	Thompson Falls to Noxon Clark Fork RM 35 to 72	Flat pool may occur during low-flow periods.
	R25	Noxon to Cabinet Gorge Clark Fork RM 15 to 34	This run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R24	Lake Pend Oreille	Lake Pend Oreille is not modeled via detailed methods. Transitional reaches exist from Albeni Falls Dam to Sandpoint, Idaho, and along from the Clark Fork River confluence to Cabinet Gorge Dam. A flat pool is assumed for the reservoir above Sandpoint, Idaho, to the Clark Fork confluence.
	R23	Albeni Falls to Box Canyon Pend Oreille RM 33 to 89	This run-of-river reservoir extends the length of the reach, but a major constriction at RM 33.7, a half-mile above the Box Canyon Dam, can produce a relatively sharp jump in water surface elevations during high-flow conditions.
	R22	Box Canyon to Boundary Dam Pend Oreille RM 16 to 33	A flat pool can be assumed for only first mile of the reach, but almost the entire length of the reach can be flat during low-flow conditions. There is a major constriction around RM 25.8 that can produce a relatively sharp jump in water surface elevations during high-flow conditions.

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CRSO Region	Reach	Reach Extents	Profile Description (e.g., flat pool, free-flowing sections, constrictions)
B. Middle Columbia	R21	U.S.-Canada Border to Grand Coulee Columbia RM 597 to 748	Roosevelt Lake operation can change pool levels by 50 to 80 feet annually. Flat pool can be assumed for 100 to 130 miles above the dam, depending on the season.
	R20	Grand Coulee to Chief Joseph Columbia RM 546 to 597	This run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R19	Chief Joseph to Wells Columbia RM 516 to 546	This run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R18	Wells to Rocky Reach Columbia RM 475 to 515	This run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R17	Rocky Reach to Rock Island Columbia RM 454 to 475	This run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R16	Rock Island to Wanapum Columbia RM 415 to 453	This run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R15	Wanapum to Priest Rapids Columbia RM 397 to 415	This run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R14 ^{2/}	Priest Rapids to Richland, Washington Columbia RM 335 to 397	Sometimes referred to as the "Hanford Reach," this reach is mostly free-flowing. The lower few miles can be influenced by Lake Wallula above McNary Dam.

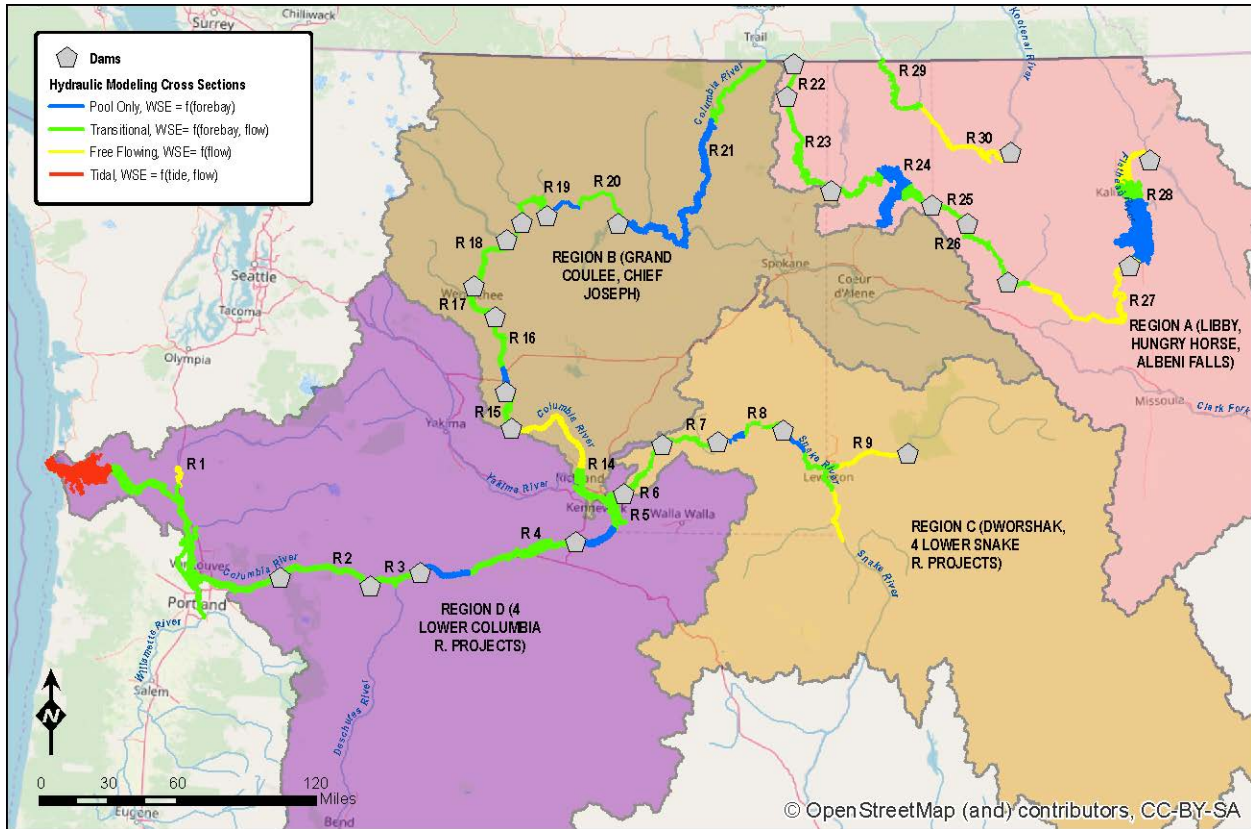
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CRSO Region	Reach	Reach Extents	Profile Description (e.g., flat pool, free-flowing sections, constrictions)
C. Lower Snake	R09	Dworshak to Lower Granite Snake RM 107 to 178 and Clearwater RM 0 to 45	Lower Granite Lake extends almost 40 miles to Lewiston, Idaho, and the Snake confluence with the Clearwater. Reservoir levels can influence Snake River water levels as far RM 145, 10 miles upstream of the confluence with the Clearwater. Free-flowing reach on the Clearwater River starts about 5 miles above confluence with Snake River.
	R08	Lower Granite to Little Goose Snake RM 70 to 106	This mostly run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R07	Little Goose to Lower Monumental Snake RM 41 to 69	This mostly run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R06	Lower Monumental to Ice Harbor Snake RM 9 to 40	This mostly run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
D. Lower Columbia	R05	Richland, Washington, and Ice Harbor to McNary Columbia RM 291 to 335 and Snake RM 0 to 8	Lake Wallula extends approximately 27 miles past Pasco, Washington. Includes Snake and Yakima River reaches for a short distance above their confluences with the Columbia. A flat pool can extend from the dam for 20 to 40 miles depending on flow conditions.
	R04	McNary to John Day Columbia RM 217 to 291	Reservoir mostly run-of-river but pool can fluctuate over 10 feet. The lower 25 miles can be assumed flat year-round, and flat pool may extend the entire reach during low-flow periods.
	R03	John Day to The Dalles Columbia RM 192 to 217	Mostly run-of-river reservoir extends the length of the reach. Flat pool may occur during low-flow periods.
	R02	The Dalles to Bonneville Columbia RM 146 to 191	Mostly run-of-river reservoir extends the length of the reach. Reach is relatively channelized with a notable constriction a couple of miles above dam (~RM 147).
	R01	Below Bonneville Columbia RM 30 to 146	Free-flowing reach from Bonneville Dam (RM 146) to RM 30 near Tongue Point, Oregon. Includes Willamette River below Oregon City Falls (RM 26), Cowlitz River below Castle Rock, Washington (RM 19) and other smaller tributaries. Tidal influence extends all the way to Bonneville Dam and partially up the major tributaries.

423 Note: RM = river mile.

424 1/ Reach 30 is combined with Reach 29 in hydraulic model "R29_30" or just "R29".

425 2/ Reach 14 is combined with Reach 5 in hydraulic model "R5_14" or just "R05".



426
427 **Figure 3-6. Map of Hydraulic Reaches Showing the Zones of Influence**
428 Note: WSE = water surface elevation. Flat pool (blue); free-flowing (yellow); transitional (green); Reach 1, which is
429 tidally influenced, is shown in red.

430 **3.2.4 Environmental Consequences**

431 **3.2.4.1 Methods**

432 The term H&H is used in a general manner to discuss the quantity, movement, or behavior of
433 water. Hydroregulation is the process water managers use to make decisions about routing
434 water through a series of dams in a river system. Computer hydroregulation modeling, also
435 called reservoir operations modeling, was used to simulate operations for the system of dams
436 in the Columbia River Basin.

437 Two hydroregulation models were used to simulate operations in the basin in support of the
438 H&H analysis: Hydro System Simulator (HydSim) and Hydrologic Engineering Center Reservoir
439 System Simulation (ResSim) software (U.S. Army Corps of Engineers [Corps] 2013). The models
440 mesh together through multiple steps to simulate operations in the Columbia River Basin.

441 The ResSim model provided FRM constraints as inputs to the HYDSIM model. Conversely, the
442 HYDSIM model provided the Columbia River Treaty operation for the Canadian projects to
443 ResSim. In addition, HYDSIM modeling provided the lack-of-market information that was
444 layered on the ResSim output to provide daily spill flow. Since both models produced flows and
445 elevations for the CRS projects, their outputs were compared to verify that they were providing

446 similar results. Details of how the models worked together are described in Appendix I,
447 *Hydroregulation Appendix*. The CRS ResSim Model is the last modeling step from which daily
448 flow and reservoir elevations are taken for analysis and use by other technical teams. While
449 operations important for determining water conditions on a seasonal and even daily basis are
450 generally modeled, certain operations such as load shaping or turbine preference are not
451 captured in the model.

452 The ResSim model for the CRS is a model that simulates reservoir releases and river flows over
453 a wide variety of hydrologic conditions. River and reservoir levels in the system are sensitive to
454 forecasted water supply volume each year, and this uncertainty is reflected in the
455 hydroregulation modeling approach used for the MOs. Details on the hydroregulation modeling
456 approach are provided in the H&H Appendix (Appendix B, Part 3, *HEC-ResSim/WAT*
457 *Documentation*).

458 The inputs used to drive the model include hydrologic datasets based on the historically
459 observed 80-year period of record (1929 to 2008), as well as synthetic hydrologic datasets to
460 represent extreme winter and spring flood events. Details on the input hydrology and runoff
461 volume forecasts used to drive the model are provided in the H&H Appendix (Appendix B, Part
462 *4, Hydrologic Data Development*).

463 The modeling process used 80 years of historical hydrology plus 26 larger synthetic years to test
464 reservoir operations. Because seasonal water supply forecasts are the biggest factor in
465 reservoir operations, each year of hydrology was run multiple times, each time with a different
466 sequence of seasonal water supply forecasts. For example, the hydrology for the year 1994 gets
467 simulated many times, but the seasonal runoff volume forecast used in the simulation is unique
468 each time that 1994 is run. Sampling of volume is done because the runoff volume forecast is a
469 driver for many reservoir operations, playing a major role in the resultant river flows over the
470 operational water year.

471 Computer hydroregulation modeling is conducted for planning studies in which operational
472 scenarios, or rules, are tested over many years of data. Each alternative has a fixed rule set, so
473 that when the model is computed each event is handled with the same rule conditions without
474 human interference to prefer different conditions. Real-world reservoir operation is complex;
475 different information is available to the water manager for decision making, and decisions are
476 shaped by an individual water manager's experience and risk tolerance. Water managers also
477 adapt operations, as possible within constraints, to an operation that meets the goals of system
478 users given the specific conditions of that particular water year⁵. Operation changes of this
479 nature are not possible to represent in a planning model, nor are they desirable, as they would
480 make comparing different MOs substantially more challenging and likely skew the results
481 towards the personal/professional opinions of what should happen.

⁵ Examples of real-time operation flexibility can include how the system may operate for fish (e.g., chum salmon spawning and incubation by changing Bonneville Dam downstream stage levels), or other purposes (e.g., summer drawdown patterns at Libby Dam for habitat restoration work downstream of the dam on the Kootenai River).

482 The hydroregulation modeling produces regulated streamflows and reservoir elevations, which
483 are used to develop summary figures and tables to describe water conditions at locations of
484 interest. Figures include summary flow hydrographs, summary elevation hydrographs, and
485 elevation duration plots. Key results are presented and described in the effects sections. The
486 H&H Appendix (Appendix B, Part 1, *H&H Data Analysis*) contains a more comprehensive set of
487 figures and tables, including an in-depth discussion of what they show.

488 With each alternative, there are several measures that were not included in the
489 hydroregulation modeling, either because the measures are not operational in nature or
490 because the reservoir operations model is not configured to simulate a given measure. For
491 example, the hydroregulation modeling results presented here do not incorporate hourly, daily,
492 or weekly load shaping which may occur at some dams. Load shaping increases project power
493 generation during peak power demand and decreases power generation during low demand
494 while passing the necessary water through the dams for the day and month flow and elevation
495 objectives. Load shaping causes outflow from a dam to generally be higher during the weekdays
496 and lower on the weekends. Load shaping within a day causes dam outflows to generally be
497 higher during the morning and evening during peak power demand, and lower during the
498 overnight period. The extent to which load shaping occurs, including sometimes not at all,
499 depends on the project and the time of year. Effects on power generation and transmission are
500 discussed in Section 3.7.3.

501 Water surface profiles and mid-reach water levels (between projects) were produced for the
502 study area. Details on the procedures used to develop these results are contained in the H&H
503 Appendix (Appendix B, Part 6, *Flow-Stage Relationship*, and Appendix B, Part 1, *H&H Data*
504 *Analysis*). The reservoir elevations, regulated streamflows, water surface profiles, and mid-
505 reach water levels produced for the MOs support the effects analyses for other resource areas
506 described throughout the EIS.

507 Summary hydrographs were also produced for the study area. A hydrograph is a graph showing
508 an indicator of water flow (such as stage or discharge) over time. One time span commonly
509 used for hydrographs, when there is need to see how water conditions change through all
510 seasons of a year, is the water year. A water year runs from October 1 through September 30. A
511 summary hydrograph is an especially useful way to display information because it shows the
512 expected range and likelihood of water levels (or flow) at a given location for each day of the
513 water year. The curves on a summary hydrograph do not represent a single water year. Rather,
514 each curve represents the percentage chance of exceeding the corresponding water level (or
515 flow) on a given day. Five exceedance levels are shown: 1 percent, 25 percent, 50 percent, 75
516 percent, and 99 percent.⁶ Select summary hydrographs are presented here in Chapter 3, and a
517 more comprehensive set of summary hydrographs and other figures, with accompanying
518 discussion, is provided in the H&H Appendix (Appendix B, Part 1, *H&H Data Analysis*).

⁶ As an example, if the 25 percent curve on a summary hydrograph says the flow on May 1 is 10 thousand cubic feet per second (kcfs), that means that flow on May 1 has a 75 percent chance of being lower than 10 kcfs and a 25 percent chance of being higher than 10 kcfs.

519 In addition to the summary hydrographs described above, a different figure is also used to
520 show how each alternative would affect water conditions in different types of water years. For
521 this purpose, figures showing median hydrographs based on water year type are used to
522 describe effects at Libby, Hungry Horse, Albeni Falls, Grand Coulee, Dworshak, and McNary
523 Dams. The plots group water years into “dry,” “average,” and “wet” years based on the April to
524 August water supply issued on May 1, then take the median flow or elevation for each day
525 within the group. Water years are categorized with respect to the forecasted seasonal runoff
526 volume percentile: dry years represent the lowest 20 percent, average years represent
527 forecasts between 20 percent and 80 percent, and wet years represent forecasts greater than
528 80 percent (same as the highest 20 percent). The figures for Libby, Hungry Horse, and Dworshak
529 Dams use their own local basin forecast volumes for the water year categorization. The figures
530 for Albeni Falls, Grand Coulee, and McNary Dams use The Dalles Dam forecast volumes for the
531 water year categorization.

532 The range of forecast volumes for each category, derived from the 5,000 water years of runoff
533 volume forecasts that were simulated, is shown in Table 3-3 below.

534 **Table 3-3. Water Year Type by Seasonal Forecast Volume**

Category	Probability Range (%)	Dworshak (kaf)	Hungry Horse (kaf)	Libby (kaf)	The Dalles (kaf)
Dry	$p \leq 20$	$\leq 1,931$	$\leq 1,433$	$\leq 5,096$	$\leq 71,462$
Average	$20 < p \leq 80$	1,932–3,349	1,433–2,305	5,101–7,647	71,466–102,298
Wet	$p > 80$	$> 3,349$	$> 2,306$	$> 7,647$	$> 102,336$

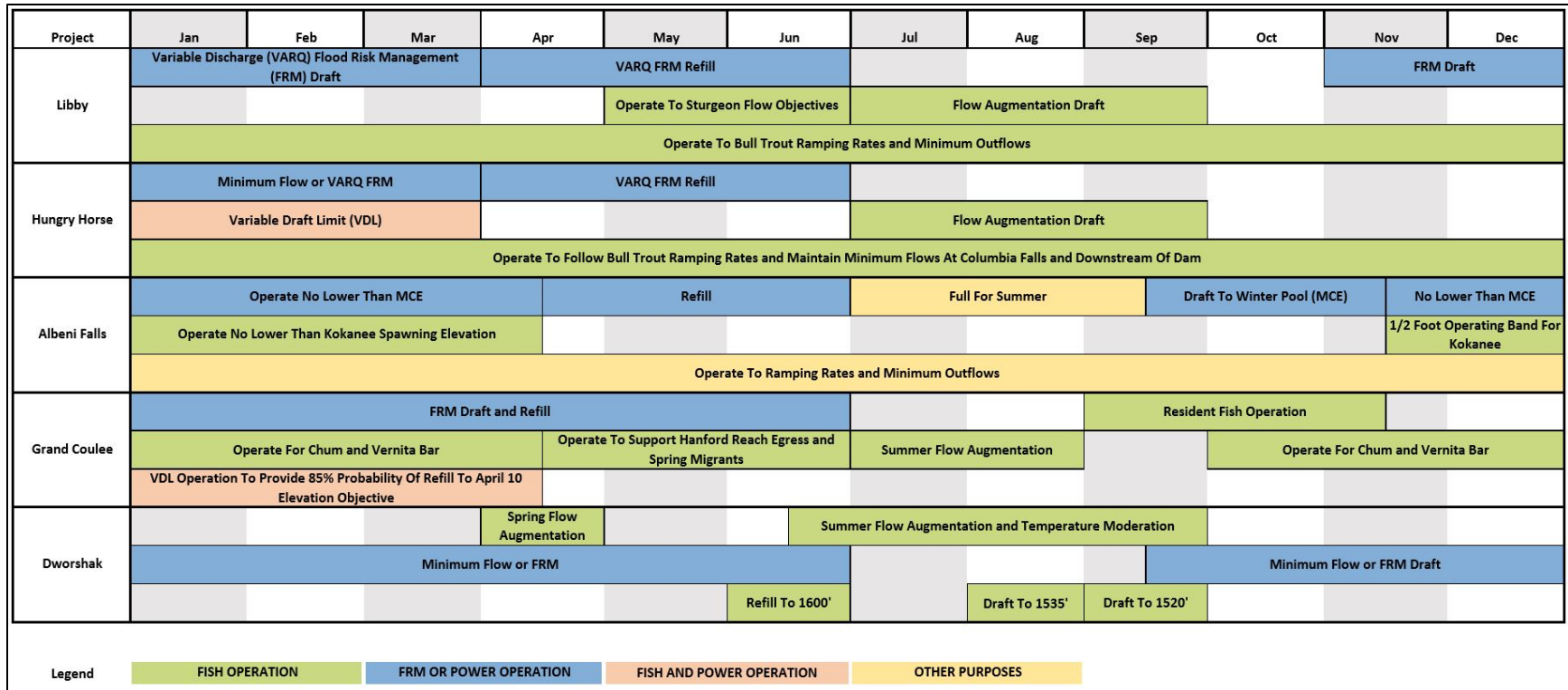
535 Note: kaf = thousand acre-feet; p = probability

536 While median hydrographs of dry, average, and wet years look similar to summary
537 hydrographs, they provide different, useful information. Summary hydrographs analyze a single
538 day over all years together, and so provide the probability of a specific occurrence, on a specific
539 day, over all modeled hydrologic events. In contrast, the median hydrographs of dry, average,
540 and wet years, group years by the May forecast value and then calculate the median value for
541 each day. Thus, they can give an indication of how a measure or combination of measures
542 would affect different types of years.

543 Figure 3-7 summarizes major groupings of operational measures for the No Action Alternative
544 at five CRS storage projects and is a useful reference for what types of operations occur at
545 these dams throughout the year. For further reading on the implementation of these
546 operational measures in hydroregulation modeling, refer to the H&H Appendix (Appendix B,
547 Part 3, *HEC-ResSim/WAT Documentation*).

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549
550

Figure 3-7. Seasonal Operations at Major Columbia River System Storage Dams

551 Throughout this EIS, reservoir water levels at the CRS dams are expressed in the National
552 Geodetic Vertical Datum of 1929 (NGVD29).⁷ River flows are expressed as volumetric flow rate
553 in kcfs. Mid-reach water levels are expressed as a stage in feet above a specified datum,
554 typically NAVD88. River miles and reach lengths are from the Corps' Columbia River Basin
555 modeling schematic.

556 **3.2.4.2 Effects (Summary)**

557 Table 3-4 provides a high-level summary of the effects the MOs would have on hydrologic
558 conditions in the study area, based on hydroregulation modeling. The key indicators used to
559 describe hydrologic conditions are reservoir elevations and regulated streamflows. Bold font is
560 used to call out indicators where there is a difference from the No Action Alternative.

561 Though it is not strictly a hydrologic effect, the effect the MOs would have on the ability to
562 conduct drum gate maintenance at Grand Coulee Dam is also presented in this section, as the
563 drum gate maintenance is directly tied to the water level of Lake Roosevelt, the reservoir
564 behind Grand Coulee Dam. Drum gate maintenance is planned to occur annually during March,
565 April, and May but is not conducted in all years. The reservoir must be at or below elevation
566 1,255 feet NGVD29 for 8 weeks to complete drum gate maintenance. The key indicator for this
567 metric is the percentage of years when drum gate maintenance would be possible. Drum gate
568 maintenance at Grand Coulee would be possible in 65 percent of years under the No Action
569 Alternative, and would not be affected by any of the MOs.

570

⁷ Notes on the NGVD29 and North American Vertical Datum of 1988 (NAVD88) datums: The Corps Engineering Regulation 1110-2-8160, Policies for Referencing Project Elevation Grades to Nationwide Vertical Datums, dated March 1, 2009, establishes the Corps policy for referencing project elevation grades to the current nationwide vertical datums, which at this time is NAVD88. Many of the CRS projects were constructed based on the mean sea level datum which is equivalent to NGVD29, the same datum used by all of the Corps projects in the Columbia River System. Individuals involved with the CRS rely heavily on this datum for all operations, and the datum is considered a legacy datum. The Engineering Regulation recognizes that the use of a legacy datum is critical to long-term H&H analyses, flood maps, and operations manuals, but that the relationship between the legacy and current datums should be documented and kept current. For the purpose of this EIS main report, the NGVD29 datum is used unless otherwise noted. As of 2019, the NGVD29 datum is lower than the NAVD88 datum by the amounts listed in Table 6-1, Vertical Datum Adjustment, located in the H&H Appendix (Appendix B, Part 3, *HEC-ResSim/WAT Documentation*).

571 **Table 3-4. Summary of Effects of Multiple Objective Alternatives Based on Hydroregulation Modeling**

Indicator	NAA	MO1	MO2	MO3	MO4
Lake Koocanusa (Libby Dam Reservoir)	Dec 31 elevation generally between 2,426.7 feet and 2,411 feet April 10 elevation between 2,410 and 2,325 feet in the middle 50% of years Median elevation for Jul, Aug, and Sep: 2,448, 2,452, and 2,450 feet, respectively	Dec 31 elevation generally at 2,420 feet (higher than NAA for most years) April 10 elevation between 2,407 and 2,332 feet in the middle 50% of years (narrower band than NAA) Median elevation for Jul, Aug, and Sep: 2,450, 2,453, and 2,451 feet, respectively (about 1–2 feet higher than NAA)	Dec 31 elevation generally at 2,400 feet (lower than NAA) April 10 elevation between 2,392 and 2,333 feet in the middle 50% of years (narrower band than NAA) Median elevation for Jul, Aug, and Sep: 2,448, 2,453, and 2,451 feet, respectively (about 0–1 foot higher than NAA)	Dec 31 elevation generally at 2,400 feet (lower than NAA) April 10 elevation between 2,392 and 2,333 feet in the middle 50% of years (narrower band than NAA) Median elevation for Jul, Aug, and Sep: 2,448, 2,453, and 2,451 feet, respectively (about 0–1 foot higher than NAA)	Dec 31 elevation generally at 2,420 feet (higher than NAA for most years) April 10 elevation between 2,408 and 2,332 feet in the middle 50% of years (narrower band than NAA and about the same as MO1) Median elevation for Jul, Aug, and Sep: 2,446, 2,448, and 2,445 feet, respectively (about 2–5 feet lower than NAA)
Libby Dam outflow	Median monthly outflow for Nov, Dec, Jan, and Feb is 14, 18, 9, and 6 kcfs, respectively Median monthly outflow for Jul, Aug, and Sep is 11, 10, and 8 kcfs, respectively	Median monthly outflow for Nov, Dec, Jan, and Feb is 15, 13, 11, and 10 kcfs, respectively (higher than NAA in Nov, Jan, and Feb; lower than NAA in Dec) Median monthly outflow for Jul, Aug, and Sep is 11, 10, and 8 kcfs, respectively (about the same as NAA)	Median monthly outflow for Nov, Dec, Jan, and Feb is 19, 20, 5, and 5 kcfs, respectively (higher than NAA in Nov and Dec; lower than NAA in Jan and Feb) Median monthly outflow for Jul, Aug, and Sep is 10, 9, and 7 kcfs, respectively (lower than NAA)	Median monthly outflow for Nov, Dec, Jan, and Feb is 19, 20, 5, and 5 kcfs, respectively (higher than NAA in Nov to Dec; lower than NAA in Jan to Feb) Median monthly outflow for Jul, Aug, and Sep is 11, 9, and 7 kcfs, respectively (lower than NAA for Aug to Sep)	Median monthly outflow for Nov, Dec, Jan, and Feb is 11, 13, 10, and 10 kcfs, respectively (lower than NAA in Nov to Dec; higher than NAA in Jan to Feb) Median monthly outflow for Jul, Aug, and Sep is 14, 10, and 8 kcfs, respectively (higher than NAA for Jul)

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Indicator	NAA	MO1	MO2	MO3	MO4
Hungry Horse Reservoir ^{1/}	<p>April 10 elevation between 3,529 and 3,506 feet in the middle 50% of years Median elevation for Jul, Aug, and Sep: 3,559, 3,556, and 3,552 feet, respectively Median elevation for Jan, Feb, Mar: 3,539, 3,532, and 3,525 feet, respectively</p>	<p>April 10 elevation between 3,525 and 3,500 feet in the middle 50% of years (Lower than NAA) Median elevation for Jul, Aug, and Sep: 3,559, 3,555, and 3,548 feet, respectively (lower than NAA for Jul to Aug) Median elevation for Jan, Feb, Mar: 3,532, 3,526, and 3,519 feet, respectively (lower than NAA)</p>	<p>April 10 elevation between 3,523 and 3,498 feet in the middle 50% of years (Lower than NAA) Median elevation for Jul, Aug, and Sep: 3,559, 3,556, and 3,552 feet, respectively (same as NAA) Median elevation for Jan, Feb, Mar: 3,535, 3,524, and 3,517 feet, respectively (lower than NAA)</p>	<p>April 10 elevation between 3,525 and 3,499 feet in the middle 50% of years (Lower than NAA; about same as MO1) Median elevation for Jul, Aug, and Sep: 3,559, 3,555, and 3,548 feet, respectively (lower than NAA for Jul to Aug; all same as MO1) Median elevation for Jan, Feb, Mar: 3,531, 3,526, and 3,518 feet, respectively (lower than NAA)</p>	<p>April 10 elevation between 3,524 and 3,499 feet in the middle 50% of years (lower than NAA; similar to MO1) Median elevation for Jul, Aug, and Sep: 3,558, 3,553, and 3,546 feet, respectively (lower than NAA; lower than MO1) Median elevation for Jan, Feb, Mar: 3,531, 3,526, and 3,518 feet, respectively (lower than NAA)</p>
Hungry Horse Dam outflow	<p>Median monthly outflow for Jul, Aug, and Sep is 3.4, 2.7, and 2.7 kcfs, respectively Median monthly outflow for Jan, Feb, and Mar is 2.6, 2.7, and 2.7 kcfs, respectively Median monthly outflow for Apr, May, and Jun is 5.4, 5.7, and 4.3 kcfs, respectively</p>	<p>Median monthly outflow for Jul, Aug, and Sep is 3.4, 3.2, and 3.2 kcfs, respectively (higher than NAA for Aug to Sep) Median monthly outflow for Jan, Feb, and Mar is 2.6, 2.6, and 2.6 kcfs, respectively (similar to NAA) Median monthly outflow for Apr, May, and Jun is 4.7, 5.3, and 3.9 kcfs, respectively (lower than NAA)</p>	<p>Median monthly outflow for Jul, Aug, and Sep is 3.1, 2.6, and 2.6 kcfs, respectively (lower than NAA for Jul to Sep) Median monthly outflow for Jan, Feb, and Mar is 5.5, 2.8, and 2.5 kcfs, respectively (higher than NAA for Jan to Feb) Median monthly outflow for Apr, May, and Jun is 4.5, 5.6, and 2.7 kcfs, respectively (lower than NAA)</p>	<p>Median monthly outflow for Jul, Aug, and Sep is 3.4, 3.2, and 3.2 kcfs, respectively (higher than NAA for Aug to Sep; all same as MO1) Median monthly outflow for Jan, Feb, and Mar is 2.6, 2.6, and 2.5 kcfs, respectively (similar to NAA) Median monthly outflow for Apr, May, and Jun is 4.4, 5.2, and 3.9 kcfs, respectively (lower than NAA)</p>	<p>Median monthly outflow for Jul, Aug, and Sep is 3.8, 3.7, and 3.7 kcfs, respectively (higher than NAA; higher than MO1) Median monthly outflow for Jan, Feb, and Mar is 2.5, 2.6, and 2.5 kcfs, respectively (similar to NAA) Median monthly outflow for Apr, May, and Jun is 4.6, 5.3, and 4.0 kcfs, respectively (lower than NAA)</p>

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Indicator	NAA	MO1	MO2	MO3	MO4
Lake Pend Oreille ^{2/}	Median elevation for Jun, Jul, Aug, and Sep: 2,061.0, 2,062.3, 2,062.3, and 2,061.6 feet respectively In lowest 40% of years, Jul and Aug elevation is 2,062.3 feet	Median elevation for Jun, Jul, Aug, and Sep: 2,061.0, 2,062.3, 2,062.3, and 2,061.6 feet, respectively (same as NAA) In lowest 40% of years, Jul and Aug elevation is 2,062.3 feet (same as NAA)	Median elevation for Jun, Jul, Aug, and Sep: 2,061.0, 2,062.3, 2,062.3, and 2,061.6 feet respectively (same as NAA) In lowest 40% of years, Jul and Aug elevation is 2,062.3 feet (same as NAA)	Median elevation for Jun, Jul, Aug, and Sep: 2,061.0, 2,062.3, 2,062.3, and 2,061.6 feet respectively (same as NAA) In lowest 40% of years, Jul and Aug elevation is 2,062.3 feet (same as NAA)	Median elevation for Jun, Jul, Aug, and Sep: 2,060.5, 2,062.3, 2,062.3, and 2,061.1 feet, respectively (lower than NAA for Jun and Sep) In lowest 40% of years, Jul and Aug elevation ranges 2,059.6–2,061.2 feet (lower than NAA)
Lake Roosevelt (Grand Coulee Dam Reservoir)	Median elevation for Dec and Jan 1,288 and 1,287 feet, respectively April 10 elevation between 1,271 and 1,245 feet in the middle 50% of years Median elevation for Jul, Aug, and Sep: 1,289, 1,282, and 1,282 feet, respectively	Median elevation for Dec and Jan 1,283 and 1,281 feet, respectively (lower than NAA) April 10 elevation between 1,268 and 1,244 feet in the middle 50% of years (lower than NAA) Median elevation for Jul, Aug, and Sep: 1,289, 1,281, and 1,282 feet, respectively (similar to NAA)	Median elevation for Dec and Jan 1,283 and 1,282 feet, respectively (lower than NAA) April 10 elevation between 1,270 and 1,244 feet in the middle 50% of years (lower than NAA) Median elevation for Jul, Aug, and Sep: 1,289, 1,281, and 1,280 feet, respectively (similar to NAA for Jul to Aug; lower than NAA for Sep)	Median elevation for Dec and Jan 1,288 and 1,288 feet, respectively (similar to NAA) April 10 elevation between 1,271 and 1,245 feet in the middle 50% of years (same as NAA) Median elevation for Jul, Aug, and Sep: 1,289, 1,281, and 1,282 feet, respectively (similar to NAA)	Median elevation for Dec and Jan 1,282 and 1,279 feet, respectively (lower than NAA) April 10 elevation between 1,270 and 1,244 feet in the middle 50% of years (lower than NAA) Median elevation for Jul, Aug, and Sep: 1,286, 1,279, and 1,279 feet, respectively (lower than NAA)

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Indicator	NAA	MO1	MO2	MO3	MO4
Grand Coulee Dam outflow	Median monthly outflow for Dec, Jan, and Feb is 97, 108, and 126 kcfs, respectively Median monthly outflow for Mar, Apr, May, Jun, Jul, and Aug is 93, 97, 138, 150, 134, and 102 kcfs, respectively	Median monthly outflow for Dec, Jan, and Feb is 101, 109, and 124 kcfs, respectively (higher than NAA in Dec ; similar to NAA in Jan; lower than NAA in Feb) Median monthly outflow for Mar, Apr, May, Jun, Jul, and Aug is 91, 93, 132, 145, 129, and 99 kcfs, respectively (lower than NAA)	Median monthly outflow for Dec, Jan, and Feb is 108, 107, and 123 kcfs, respectively (higher than NAA in Dec ; similar to NAA in Jan; lower than NAA in Feb) Median monthly outflow for Mar, Apr, May, Jun, Jul, and Aug is 88, 95, 134, 148, 133, and 101 kcfs, respectively (lower than NAA)	Median monthly outflow for Dec, Jan, and Feb is 100, 103, and 126 kcfs, respectively (higher than NAA in Dec ; lower than NAA in Jan ; same as NAA in Feb) Median monthly outflow for Mar, Apr, May, Jun, Jul, and Aug is 91, 92, 132, 145, 129, and 99 kcfs, respectively (lower than NAA)	Median monthly outflow for Dec, Jan, and Feb is 99, 110, and 122 kcfs, respectively (higher than NAA in Dec and Jan ; lower than NAA in Feb) Median monthly outflow for Mar, Apr, May, Jun, Jul, and Aug is 91, 92, 136, 149, 133, and 100 kcfs, respectively (lower than NAA)
Dworshak Reservoir	Median elevation for Jan, Feb, Mar, Apr, and May: 1,527, 1,521, 1,518, 1,519, and 1,554 feet, respectively Median elevation for Jun, Jul, Aug, and Sep: 1,596, 1,589, 1,555, and 1,522 feet, respectively	Median elevation for Jan, Feb, Mar, Apr, and May: 1,527, 1,521, 1,518, 1,519, and 1,554 feet, respectively (same as NAA) Median elevation for Jun, Jul, Aug, and Sep: 1,595, 1,583, 1,552, and 1,530 feet, respectively (lower than NAA in Jun to Aug ; higher than NAA in Sep)	Median elevation for Jan, Feb, Mar, Apr, and May: 1,519, 1,505, 1,492, 1,501, and 1,544 feet, respectively (lower than NAA in Jan to Apr ; same as NAA in May) Median elevation for Jun, Jul, Aug, and Sep: 1,590, 1,585, 1,553, and 1,522 feet, respectively (lower than NAA in Jun to Aug)	Median elevation for Jan, Feb, Mar, Apr, and May: 1,527, 1,521, 1,518, 1,519, and 1,554 feet, respectively (same as NAA) Median elevation for Jun, Jul, Aug, and Sep: 1,596, 1,589, 1,555, and 1,522 feet, respectively (same as NAA)	Median elevation for Jan, Feb, Mar, Apr, and May: 1,527, 1,521, 1,518, 1,519, and 1,554 feet, respectively (same as NAA) Median elevation for Jun, Jul, Aug, and Sep: 1,596, 1,589, 1,555, and 1,522 feet, respectively (same as NAA)

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Indicator	NAA	MO1	MO2	MO3	MO4
Dworshak Dam outflow	Median monthly outflow for Jan, Feb, Mar, Apr, and May is 2.1, 5.1, 6.2, 9.6, and 3.5 kcfs, respectively Median monthly outflow for Jun, Jul, Aug, and Sep is 4.8, 10.7, 10.2, and 5.0 kcfs, respectively	Median monthly outflow for Jan, Feb, Mar, Apr, and May is 2.1, 5.1, 6.3, 9.6, and 3.5 kcfs, respectively (similar to NAA) Median monthly outflow for Jun, Jul, Aug, and Sep is 6.4, 12.3, 5.2, and 6.8 kcfs, respectively (higher than NAA in Jun, Jul, and Sep; lower than NAA in Aug)	Median monthly outflow for Jan, Feb, Mar, Apr, and May is 8.8, 7.1, 4.8, 7.7, and 4.5 kcfs, respectively (higher than NAA in Jan to Feb and May; lower than NAA in Mar to Apr) Median monthly outflow for Jun, Jul, Aug, and Sep is 2.7, 10.5, 9.8, and 4.9 kcfs, respectively (lower than NAA in Jun, Jul, and Aug; similar to NAA in Sep)	Median monthly outflow for Jan, Feb, Mar, Apr, and May is 2.1, 5.1, 6.2, 9.6, and 3.5 kcfs, respectively (same as NAA) Median monthly outflow for Jun, Jul, Aug, and Sep is 4.8, 10.7, 10.1, and 5.0 kcfs, respectively (similar to NAA)	Median monthly outflow for Jan, Feb, Mar, Apr, and May is 2.1, 5.1, 6.2, 9.6, and 3.5 kcfs, respectively (same as NAA) Median monthly outflow for Jun, Jul, Aug, and Sep is 4.9, 10.7, 10.2, and 5.0 kcfs, respectively (similar to NAA)
Lower Granite Dam Reservoir ^{3/}	Normal operating range 733.0–738.0 feet 1-foot MOP range (733.0–734.0 feet) from Apr 3 to Aug 31 Modeled elevation 733.5 feet Apr 3 to Aug 31	1.5-foot MOP range from Apr 3 to Aug 31 (733.0–734.5 feet) (broader range than NAA, up to 0.5 foot higher)	Normal operating range year round (733.0–738.0 feet), no MOP (broader range than NAA from Apr 3 to Aug 31)	Dam breached	1.5-foot MOP range from Mar 15 to Aug 15 (733.0–734.5 feet) (broader range than NAA, up to 0.5 foot higher)
Little Goose Dam Reservoir ^{3/}	Normal operating range 633.0–638.0 feet 1-foot MOP range (633.0–634.0 feet) from Apr 3 to Aug 31 Modeled elevation 633.5 feet from Apr 3 to Aug 31	1.5-foot MOP range from Apr 3 to Aug 31 (633.0–634.5 feet) (broader range than NAA, up to 0.5 foot higher)	Normal operating range year round (633.0–638.0 feet), no MOP (broader range than NAA from Apr 3 to Aug 31)	Dam breached	1.5-foot MOP range from Mar 15 to Aug 15 (633.0–634.5 feet) (broader range than NAA, up to 0.5 foot higher)

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Indicator	NAA	MO1	MO2	MO3	MO4
Lower Monumental Dam Reservoir ^{3/}	Normal operating range 537.0–540.0 feet 1-foot MOP range (537.0–538.0 feet) from Apr 3 to Aug 31 Modeled elevation 537.5 feet from Apr 3 to Aug 31	1.5-foot MOP range from Apr 3 to Aug 31 (537.0–538.5 feet) (broader range than NAA, up to 0.5 foot higher)	Normal operating range year round (537.0–540.0 feet), no MOP (broader range than NAA from Apr 3 to Aug 31)	Dam breached	1.5-foot MOP range from Mar 15 to Aug 15 (537.0–538.5 feet) (broader range than NAA, up to 0.5 foot higher)
Ice Harbor Dam Reservoir ^{3/}	Normal operating range 437.0 to 440.0 feet 1-foot MOP range (437.0–438.0 feet) from Apr 3 to Aug 31 Modeled elevation 437.5 feet from Apr 3 to Aug 31	1.5-foot MOP range from Apr 3 to Aug 31 (437.0 to 438.5 feet) (broader range than NAA, up to 0.5 foot higher)	Normal operating range year round (437.0 to 440.0 feet), no MOP (broader range than NAA from Apr 3 to Aug 31)	Dam breached	1.5-foot MOP range from Mar 15 to Aug 15 (437.0 to 438.5 feet) (broader range than NAA, up to 0.5 foot higher)
McNary Dam outflow	75% of the time, the monthly average outflow for May, Jun, and Jul exceeds 231, 217, and 146 kcfs, respectively	75% of the time, the monthly average outflow for May, Jun, and Jul exceeds 226, 216, and 146 kcfs, respectively (lower than NAA in May to Jun; same as NAA in July)	75% of the time, the monthly average outflow for May, Jun, and Jul exceeds 229, 213, and 146 kcfs, respectively (lower than NAA in May to Jun; same as NAA in July)	75% of the time, the monthly average outflow for May, Jun, and Jul exceeds 225, 213, and 142 kcfs, respectively (lower than NAA)	75% of the time, the monthly average outflow for May, Jun, and Jul exceeds 234, 226, and 153 kcfs, respectively (higher than NAA)

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Indicator	NAA	MO1	MO2	MO3	MO4
Lake Umatilla (John Day Dam Reservoir) ^{4/}	Normal operating range: 262.5–265.0 feet from Oct 1 to Nov 14, 262.0–266.5 feet from Nov 15 to Dec 31, 262.0–265.0 feet from Jan 1 to Mar 14, 262.5–265.0 feet from Mar 15 to Apr 9 1.5-foot MIP range (262.5–264.0 feet) from Apr 10 to Sep 30 Full operating range for FRM 257.0–268.0 feet	1.5-foot MIP range from Apr 1 to May 31 (263.5–265.0 feet) (up to 1 foot higher and earlier start than NAA) 2.0-foot MIP range (262.5–264.5) from Jun 1 to Sep 30 (broader and higher range than NAA)	Operating range goes up to 266.5 feet year round except as needed for FRM (broader range than NAA)	Operating range goes up to 266.5 feet year round except as needed for FRM (broader range than NAA)	1.5-foot range (261.0–262.5 feet) from Mar 25 to Aug 15 (lower than NAA)

572 Note: FRM = flood risk management; MIP = minimum irrigation pool; MOP = minimum operating pool.

573 1/ When MO1 and MO3 were modeled, the initial Hungry Horse Reservoir levels at the start of each water year were erroneously set lower than intended. The
574 expected elevations from October through May would actually be 1 to 3 feet higher than shown in this table for those two MOs.

575 2/ The typical summer elevation range for Lake Pend Oreille is 2,062.0 to 2,062.5 feet NVGD29. It is represented as 2,062.25 feet NGVD29 in the HEC-ResSim
576 model, so appears as 2,062.3 feet NGVD29 in this table.

577 3/ MO1, MO2, and MO4 changes are not reflected in ResSim modeling.

578 4/ MO2 and MO3 changes are not reflected in ResSim modeling.

579 Other dam maintenance activities affected by water levels (including discussion of the
580 metrics/indicators for ability to conduct maintenance) are discussed in the H&H Appendix
581 (Appendix B, Part 1, *H&H Data Analysis*) and/or the Water Quality Appendix (Appendix D).
582 These include maintenance of the 57-inch butterfly drum gate intake valves at Grand Coulee
583 Dam, maintenance of the selective withdrawal structure at Hungry Horse Dam, and general
584 power plant maintenance activities.

585 The amount of water spilled at each project was modeled using a spill allocation methodology
586 described in the H&H Appendix (Appendix B, Part 2, *Spill*). Table 3-5 summarizes the spill
587 operations for the MOs. Further details and modeling results from the extended year dataset
588 (water years 2008 through 2016) are presented and discussed in the H&H Appendix (Appendix
589 B, Part 2, *Spill Analysis*).

590 **Table 3-5. Summary of Spill Operations**

Project	Alternative	Start Date	End Date	Spill Operation
Bonneville (Region D)	NAA	April 10	June 15	100 kcfs
		June 16	August 31	Alternating between 85/121 kcfs day/night and 95 kcfs in 2 day treatments
	MO1 (Base)	April 10	June 15	100 kcfs
		June 16	August 31	95 kcfs
	MO1 (Test)	April 10	June 15	122–126 kcfs (120%/115% TDG)
		June 16	August 31	95 kcfs
	MO2	April 10	July 31	50 kcfs (minimum limit of gate spill flow)
	MO3	April 10	June 15	122–155 kcfs
		June 16	July 31	Alternating between 85/121 kcfs day/night and 95 kcfs in 2 day treatments
	MO4	March 1	August 31	223–252 kcfs (125% Gas Cap)
October 1		November 30	8 kcfs (Spillway Weir Notch)	
The Dalles (Region D)	NAA	April 10	August 31	40% Total Outflow
	MO1 (Base)	April 10	August 31	40% Total Outflow
	MO1 (Test)	April 10	June 15	96 kcfs (120%/115% TDG)
		June 16	August 31	40% Total Outflow
	MO2	April 10	July 31	40% Total Outflow (Limited by 110% TDG, 19–29 kcfs)
	MO3	April 10	June 15	118–147 kcfs (120 % TDG)
		June 16	July 31	40% Total Outflow
	MO4	March 1	August 31	229–246 kcfs (125% Gas Cap)
		October 1	November 30	8 kcfs (Spillway Weir Notch)

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Project	Alternative	Start Date	End Date	Spill Operation
John Day (Region D)	NAA	April 10	April 26	30% Total Outflow
		April 27	July 20	Alternating between 30% and 40% in 2 day treatments
		July 21	August 31	30% Total Outflow
	MO1 (Base)	April 10	June 15	32% Total Outflow
		June 16	August 31	35% Total Outflow
	MO1 (Test)	April 10	June 15	110 kcfs (120%/115% TDG)
		June 16	August 31	35% Total Outflow
	MO2	April 10	July 31	30% Total Outflow (Limited by 115% TDG due to dangerous eddies when spill < 30% total outflow, 40–78 kcfs)
		April 10	July 31	8 kcfs (Powerhouse Bypass)
	MO3	April 10	June 15	147–155 kcfs (120% TDG)
		June 16	July 31	30% Total Outflow
	MO4	March 1	August 31	200–208 kcfs (125% Gas Cap)
		March 1	August 31	8 kcfs (Powerhouse Bypass)
		October 1	November 30	8 kcfs (Spillway Weir Notch)
	McNary (Region D)	NAA	April 10	June 15
June 16			August 31	50% Total Outflow
MO1 (Base)		March 1	August 31	8 kcfs (Powerhouse Bypass)
		April 10	June 15	48% Total Outflow
		June 16	August 31	57% Total Outflow
MO1 (Test)		March 1	August 31	8 kcfs (Powerhouse Bypass)
		April 10	June 15	164 kcfs (120%/115% TDG)
		June 16	August 31	57% Total Outflow
MO2		April 10	July 31	14–22 kcfs (ASW flows override 110% TDG)
		April 10	July 31	8 kcfs (Powerhouse Bypass)
MO3		April 10	June 15	172–189 kcfs (120% TDG)
		June 16	July 31	50% Total Outflow
		March 1	August 31	8 kcfs (Powerhouse Bypass)
MO4		March 1	August 31	266–272 kcfs (125% TDG)
		March 1	August 31	8 kcfs (Powerhouse Bypass)
	October 1	November 30	8 kcfs (Spillway Weir Notch)	

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Project	Alternative	Start Date	End Date	Spill Operation
Ice Harbor ^{1/} (Region C)	NAA	April 3	April 27	45 kcfs day/gas cap night
		April 28	July 13	Alternating between 45 kcfs/gas cap day/night and 30% in 2 day treatments
		July 14	August 31	45 kcfs day/gas cap night
	MO1 (Base)	March 1	August 31	4 kcfs (Powerhouse Bypass)
		April 3	June 20	30% Total Outflow
		June 21	August 6	30% Total Outflow
	MO1 (Test)	March 1	August 31	4 kcfs (Powerhouse Bypass)
		April 3	June 20	86 kcfs (120%/115% TDG)
		June 21	August 6	30% Total Outflow
	MO2	April 3	July 31	7–11 kcfs (ASW flows override 110% TDG)
		April 3	July 31	4 kcfs (Powerhouse Bypass)
	MO4	March 1	August 31	118–129 kcfs (125% TDG)
		March 1	August 31	4 kcfs (Powerhouse Bypass)
		October 1	November 30	2 kcfs (Spillway Weir Notch)
	Lower Monumental ^{1/} (Region C)	NAA	April 3	June 20
June 21			August 31	17 kcfs
MO1 (Base)		April 3	June 20	26 kcfs
		June 21	August 6	17 kcfs
MO1 (Test)		April 3	June 20	33 kcfs (120/115% TDG)
		June 21	August 6	17 kcfs
MO2		April 3	July 31	7–12 kcfs (110% TDG, ASW flows override in July)
MO4		March 1	August 31	99–104 kcfs (125% TDG)
		March 1	August 31	4 kcfs (Powerhouse Bypass)
		October 1	November 30	2 kcfs (Spillway Weir Notch)
Little Goose ^{1/} (Region C)	NAA	April 3	August 31	30% Total Outflow
	MO1 (Base)	April 3	August 21	30% Total Outflow
	MO1 (Test)	April 3	June 20	30 kcfs (120/115% TDG)
		June 21	August 21	30% Total Outflow
	MO2	April 3	July 31	7.2–23 kcfs (110% TDG, ASW flows override in July)
	MO4	March 1	August 31	82–83 kcfs (125% TDG)
		March 1	August 31	4 kcfs (Powerhouse Bypass)
		October 1	November 30	2 kcfs (Spillway Weir Notch)

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Project	Alternative	Start Date	End Date	Spill Operation
Lower Granite ^{1/} (Region C)	NAA	April 3	June 20	20 kcfs
		June 21	August 31	18 kcfs
	MO1 (Base)	April 3	June 20	20 kcfs
		June 21	August 18	18 kcfs
	MO1 (Test)	April 3	June 20	35 kcfs (120%/115% TDG)
		June 21	August 18	18 kcfs
	MO2	April 3	July 31	7–16 kcfs (110% TDG)
	MO4	March 1	August 31	73–74 kcfs (125% TDG)
		March 1	August 31	4 kcfs (Powerhouse Bypass)
October 1		November 30	2 kcfs (Spillway Weir Notch)	
Priest Rapids ^{2/} (Region B)	All Alternatives	April 16	August 23	24 kcfs
		August 24	November 15	2.8 kcfs
		November 16	November 30	1.8 kcfs
		December 1	December 31	0.2 kcfs
		January 1	January 31	0.2 kcfs
		February 1	March 15	1.1 kcfs
		March 16	April 15	1.8 kcfs
Wanapum ^{2/} (Region B)	All Alternatives	April 16	August 23	20 kcfs
		August 24	November 15	3.4 kcfs
		November 16	November 30	1.7 kcfs
		December 1	December 31	0.8 kcfs
		January 1	January 31	0.8 kcfs
		February 1	March 15	1.2 kcfs
		March 16	April 15	1.7 kcfs
Rock Island ^{2/} (Region B)	All Alternatives	July 1	August 15	20% Total Outflow
		August 16	August 31	6.3% Total Outflow
		April 15	April 30	9.3% Total Outflow
		May 1	May 31	10% Total Outflow
		June 1	June 30	18% Total Outflow
Wells ^{2/} (Region B)	All Alternatives	April 12	August 26	If Chief Joseph Total Outflow greater than 140 kcfs, 6.5% total outflow. Otherwise, 10.2 kcfs.
Libby (Region A)	All Alternatives	–	–	No fish spill
Hungry Horse (Region A)	All Alternatives	–	–	No fish spill
Dworshak (Region C)	All Alternatives	–	–	No fish spill
Albeni Falls (Region A)	All Alternatives	–	–	No fish spill
Grand Coulee (Region B)	All Alternatives	–	–	No fish spill

Project	Alternative	Start Date	End Date	Spill Operation
Chief Joseph (Region B)	All Alternatives	–	–	No fish spill

591 Note: ASW = adjustable spillway weir; TDG = total dissolved gas.

592 1/ Under MO3, the four lower Snake River projects (Ice Harbor, Lower Monumental, Little Goose, and Lower
593 Granite) would be breached; therefore, no spill operations exist for these projects.

594 2/ These dams on the middle Columbia River are not CRS projects, but are included in this table for completeness
595 in describing fish spill operations.

596 The effects associated with each MO are discussed in the subsequent H&H Environmental
597 Consequences sections (Sections 3.2.4.4 through 3.2.4.7). The effects associated with the No
598 Action Alternative are discussed in Section 3.2.4.3, with additional detail on the No Action
599 Alternative also included in Sections 3.2.4.4 through 3.2.4.7 where each MO is discussed. As
600 MO1, MO2, MO3, and MO4 are each discussed, the operational measure (or measures) which
601 would result in changes from the No Action Alternative are identified to the extent possible. For
602 a comparison of model results from the various alternatives, see the H&H Appendix (Appendix
603 B, Part 1, *H&H Data Analysis*) for additional discussion and a comprehensive set of tables and
604 plots.

605 **3.2.4.3 No Action Alternative**

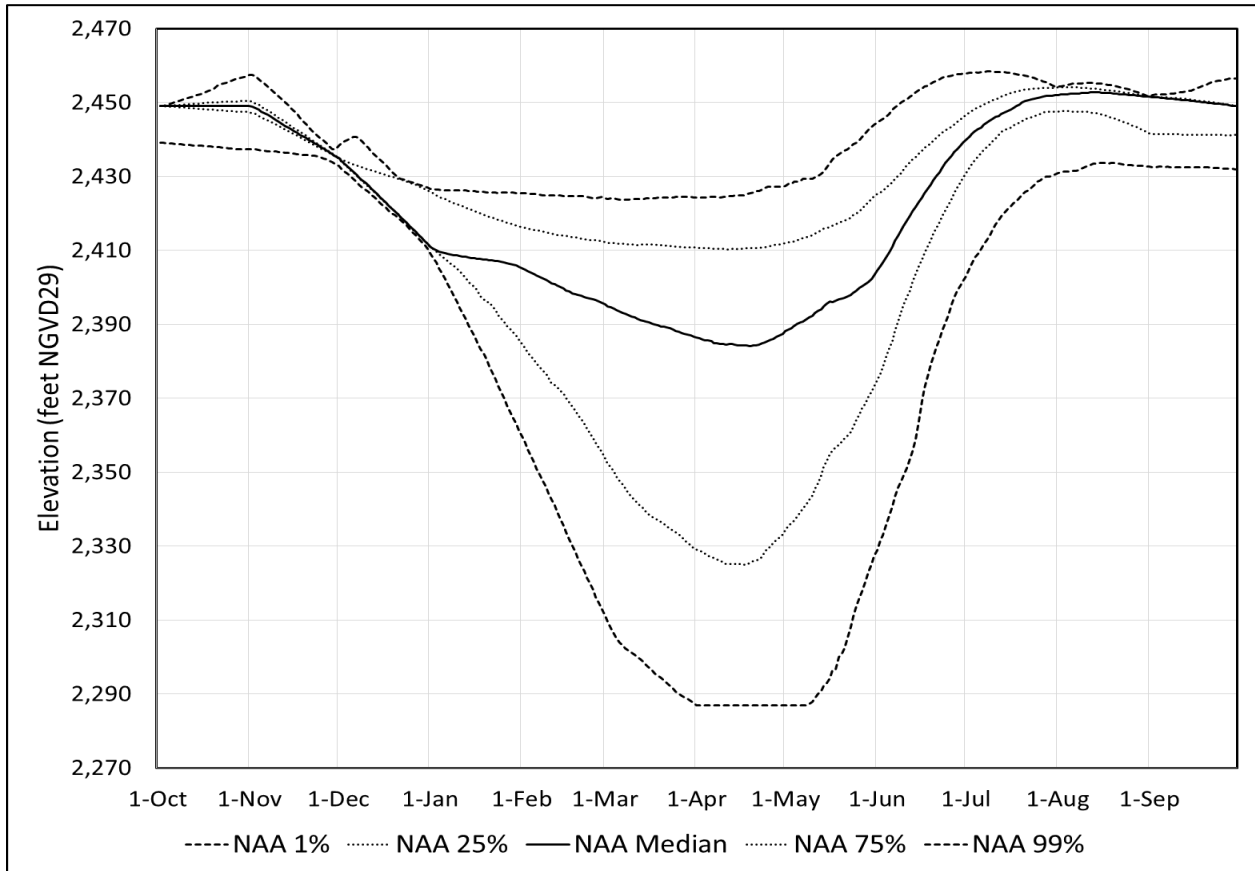
606 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

607 **Lake Kocanusa (Libby Dam Reservoir) Elevation**

608 The reservoir behind Libby Dam is called Lake Kocanusa. The summary hydrograph showing
609 Lake Kocanusa elevations for the No Action Alternative is shown in Figure 3-8. In this and
610 other summary hydrographs presented for reservoirs, the 1 percent exceedance level
611 represents the highest elevations; 99 percent represents the lowest. For instance, looking at
612 the figure below, one can see that on June 1, the 99 percent exceedance level curve
613 corresponds to an elevation of about 2,330 feet NGVD29. That means there is a 99 percent
614 chance the reservoir will be higher than 2,330 feet NGVD29 on June 1, and 1 percent chance it
615 will be lower than 2,330 feet NGVD29 on June 1.

616 There would not be much variability in water levels in October and November. In December,
617 the range of the reservoir water level begins to spread, as the end of December FRM elevation
618 for Libby Dam is based on a seasonal water supply forecast that is issued at the beginning of
619 December. The range of possible reservoir elevations widens further in the subsequent winter
620 months, lasting into the early spring. The drawdown of the reservoir level that occurs in the
621 winter and early spring months is guided by variable discharge storage regulation procedure
622 (VarQ) FRM requirements, and also by minimum outflow requirements. The reservoir usually
623 begins refilling by April or May and reaches its peak elevation in July. Libby Dam releases water
624 and drafts over the summer to help meet flow objectives in the lower Columbia River for
625 juvenile anadromous fish migration. The elevation objective at the end of September is either
626 elevation 2,449 feet NGVD29 or elevation 2,439 feet NGVD29. The elevation objective of 2,439

627 feet NGVD29 applies in the driest 20 percent of years,⁸ based on the May issued April to August
628 water supply forecast at The Dalles. In all other years, the elevation objective of 2,449 feet
629 NGVD29 applies.



630
631 **Figure 3-8. Lake Kocanusa Summary Hydrograph for No Action Alternative**

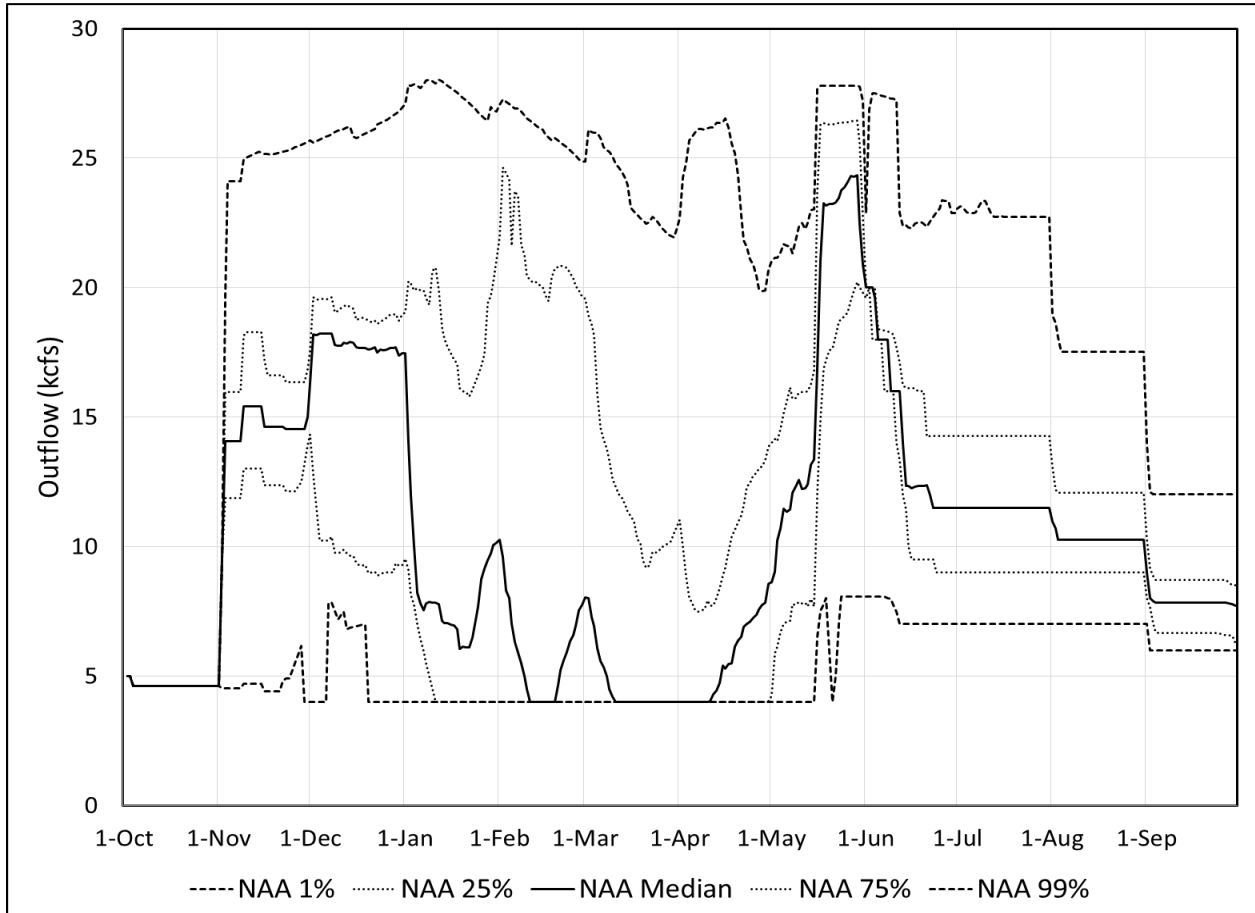
632 **Libby Dam Outflow**

633 A summary hydrograph showing outflow from Libby Dam for the No Action Alternative is shown
634 in Figure 3-9.

635 Outflow in October is typically less than 5 kcfs. It increases in November and usually increases
636 again in December, though not always. From January through March, the range of outflow from
637 Libby Dam can be quite wide, as seen in the difference between the 25th percentile and 75th
638 percentile lines on the Figure 3-9 summary hydrograph. By about mid-May, there is usually a
639 pronounced increase in Libby Dam outflow for several weeks to provide flows for Kootenai
640 River white sturgeon. Following the pronounced increase, the outflow gradually decreases over
641 the remaining months of the water year. In addition to outflows for Kootenai River white
642 sturgeon in the late spring, operations are also guided by meeting minimum bull trout flow

⁸ This driest 20 percent of years is based off the most recent 30-year period statistics developed by the National Oceanic and Atmospheric Administration (NOAA).

643 requirements from May 15 through September 30, and also the end of September reservoir
644 elevation objective for anadromous fish migration on the lower Columbia River.

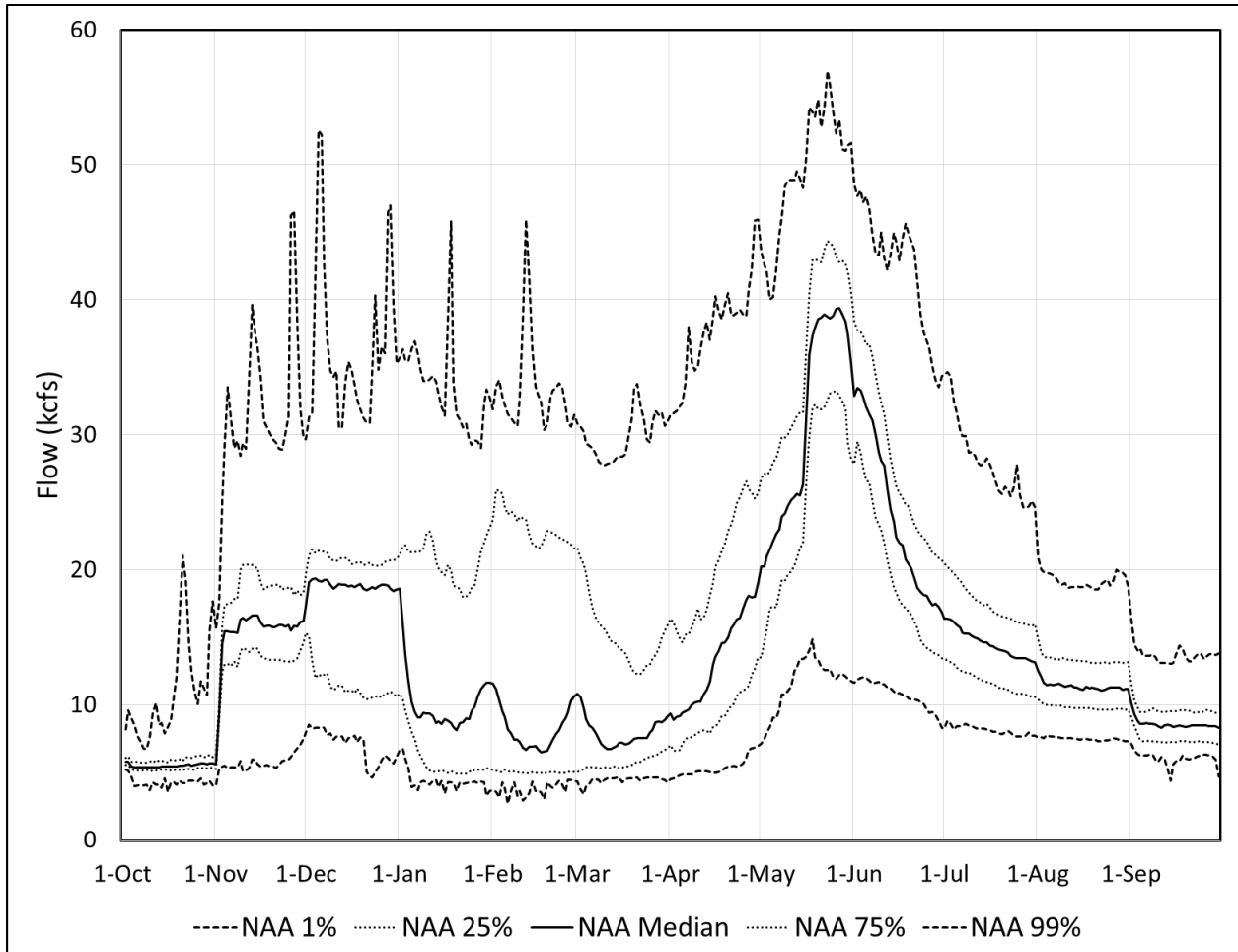


645
646 **Figure 3-9. Libby Dam Outflow Summary Hydrograph for No Action Alternative**

647 **Bonnerr Ferry Flow**

648 A summary hydrograph showing the flow at Bonners Ferry, Idaho, for the No Action Alternative
649 is shown in Figure 3-10.

650 Bonners Ferry is located along the Kootenai River, approximately 70 river miles downstream of
651 Libby Dam. The general pattern throughout most of the water year is similar to that for Libby
652 Dam outflow. In the late spring and early summer, flows at Bonners Ferry are consistently much
653 higher than the Libby Dam outflow, when the spring freshet adds more local runoff to the
654 Kootenai River downstream of Libby Dam.



655

656

Figure 3-10. Bonners Ferry Flow Summary Hydrograph for No Action Alternative

657

Hungry Horse Reservoir Elevation

658

A summary hydrograph showing Hungry Horse Reservoir elevations for the No Action

659

Alternative is shown in Figure 3-11.

660

There is not much variability in water levels at the start of the water year. Over the next several

661

months, the range of the reservoir water level begins to spread, as Hungry Horse is operated to

662

meet minimum flows and continues to draft depending on inflow conditions. The range of

663

possible reservoir elevations widens further in the subsequent winter months, lasting into the

664

early spring. The drawdown of the reservoir level that occurs in the winter and early spring

665

months is guided by VarQ FRM requirements. In real time, however, the reservoir may also be

666

deeper than the VarQ FRM elevation to operate for power, so long as there is a 75 percent

667

chance of being at the elevation objective on April 10 (this is referred to as a variable draft

668

limit). The reservoir is also deeper than the VarQ FRM elevation when needed to meet

669

minimum flows for bull trout on the South Fork Flathead River and on the mainstem Flathead

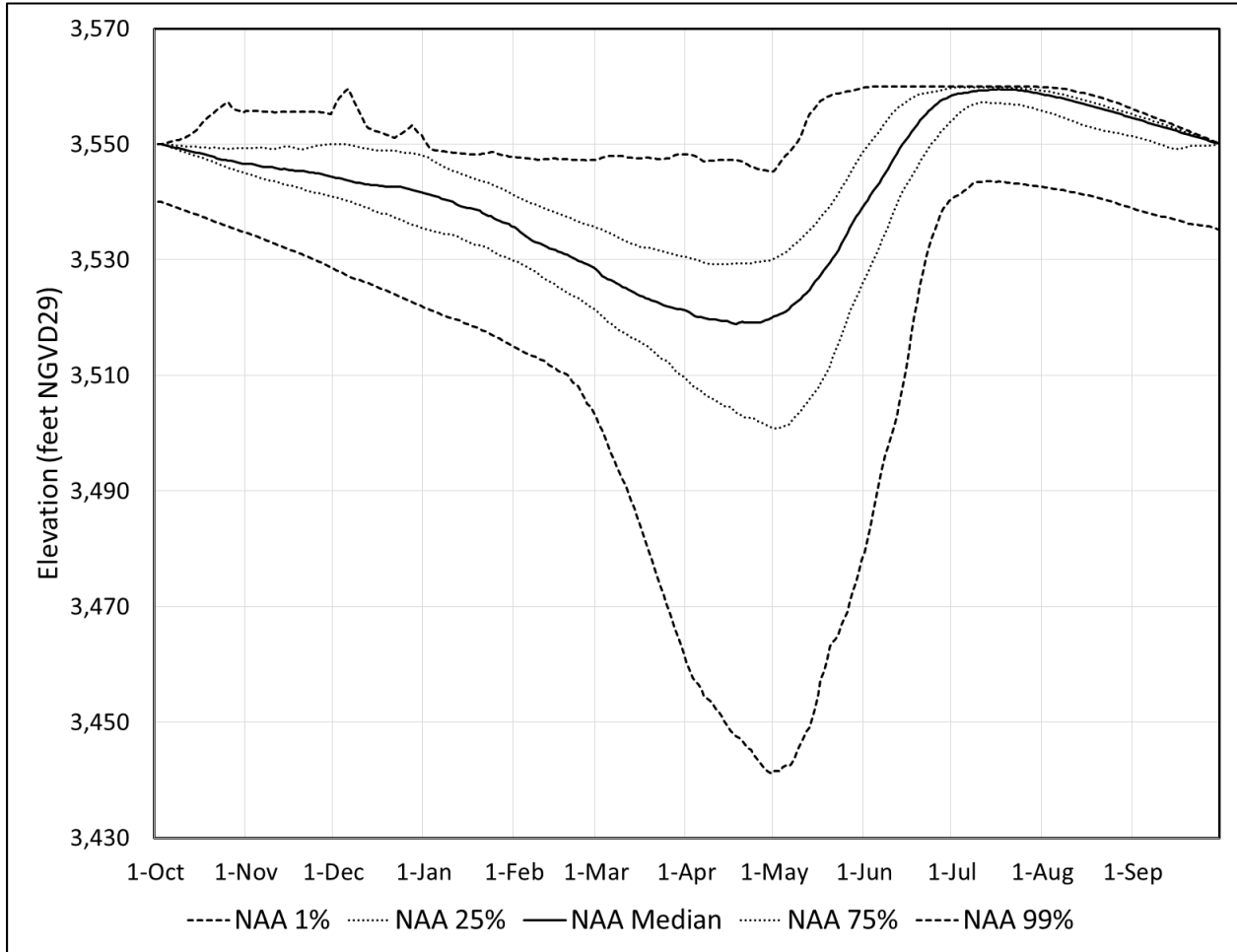
670

River at Columbia Falls. The reservoir typically experiences the deepest draft point in late April

671

or early May to satisfy VarQ FRM requirements. The reservoir usually begins refilling in early

672 May and reaches its peak elevation in late June to early July. Hungry Horse Dam releases water
 673 and drafts over the summer to help meet flow objectives in the lower Columbia River for
 674 juvenile anadromous fish migration. The elevation objective at the end of September is either
 675 elevation 3,550 feet NGVD29 or elevation 3,540 feet NGVD29. The elevation objective of 3,540
 676 feet NGVD29 applies in the driest 20 percent of years⁹, based on the May issued April to August
 677 water supply forecast at The Dalles. In all other years, the elevation objective of 3,550 feet
 678 NGVD29 applies. In dry years, the need to satisfy local minimum flow requirements can cause
 679 the reservoir to be lower than its end of September elevation objective.

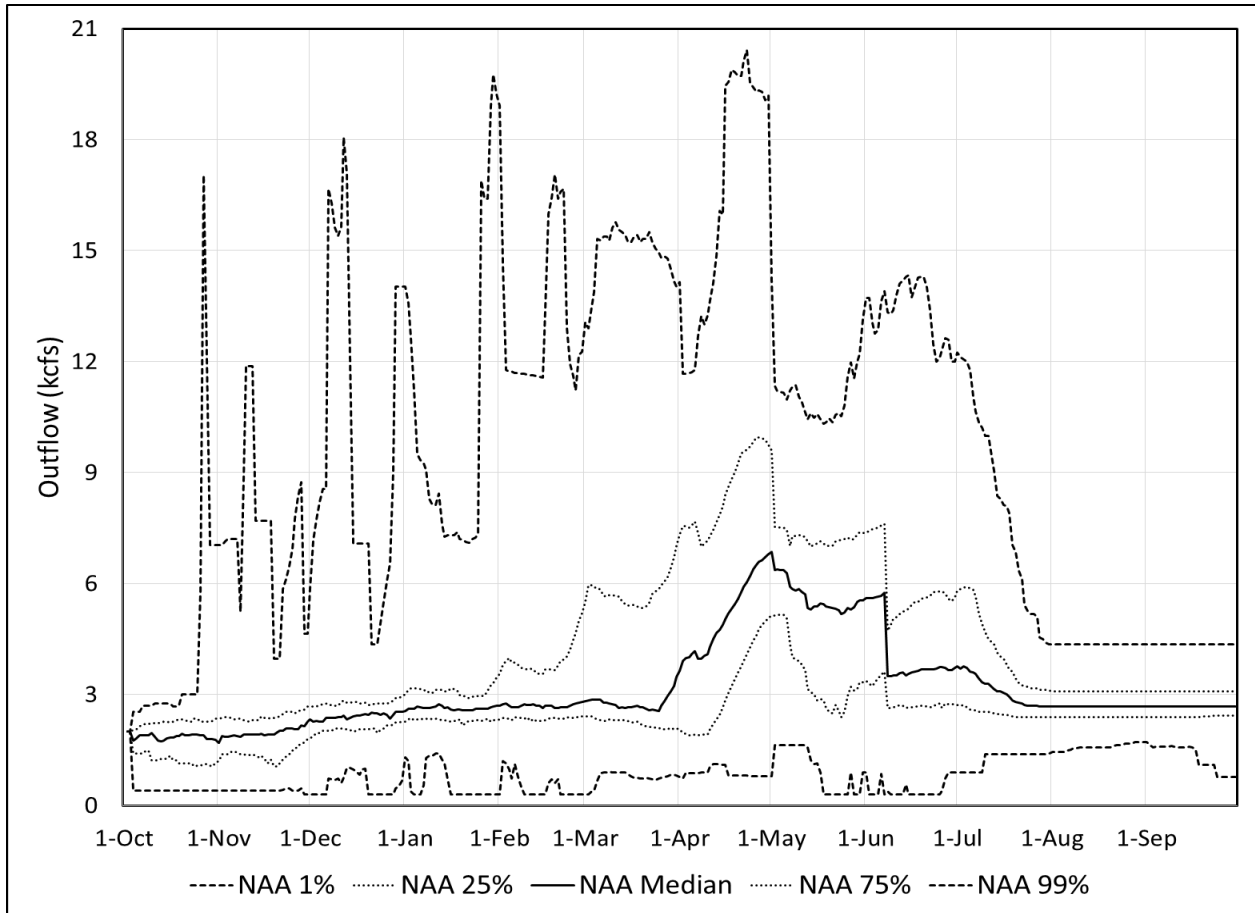


680
 681 **Figure 3-11. Hungry Horse Reservoir Summary Hydrograph for No Action Alternative**

682 **Hungry Horse Dam Outflow**

683 A summary hydrograph showing outflow from Hungry Horse Dam for the No Action Alternative
 684 is shown in Figure 3-12.

⁹ This driest 20 percent of years is based off the most recent 30-year period statistics developed by NOAA.



685
 686

Figure 3-12. Hungry Horse Dam Outflow Summary Hydrograph for No Action Alternative

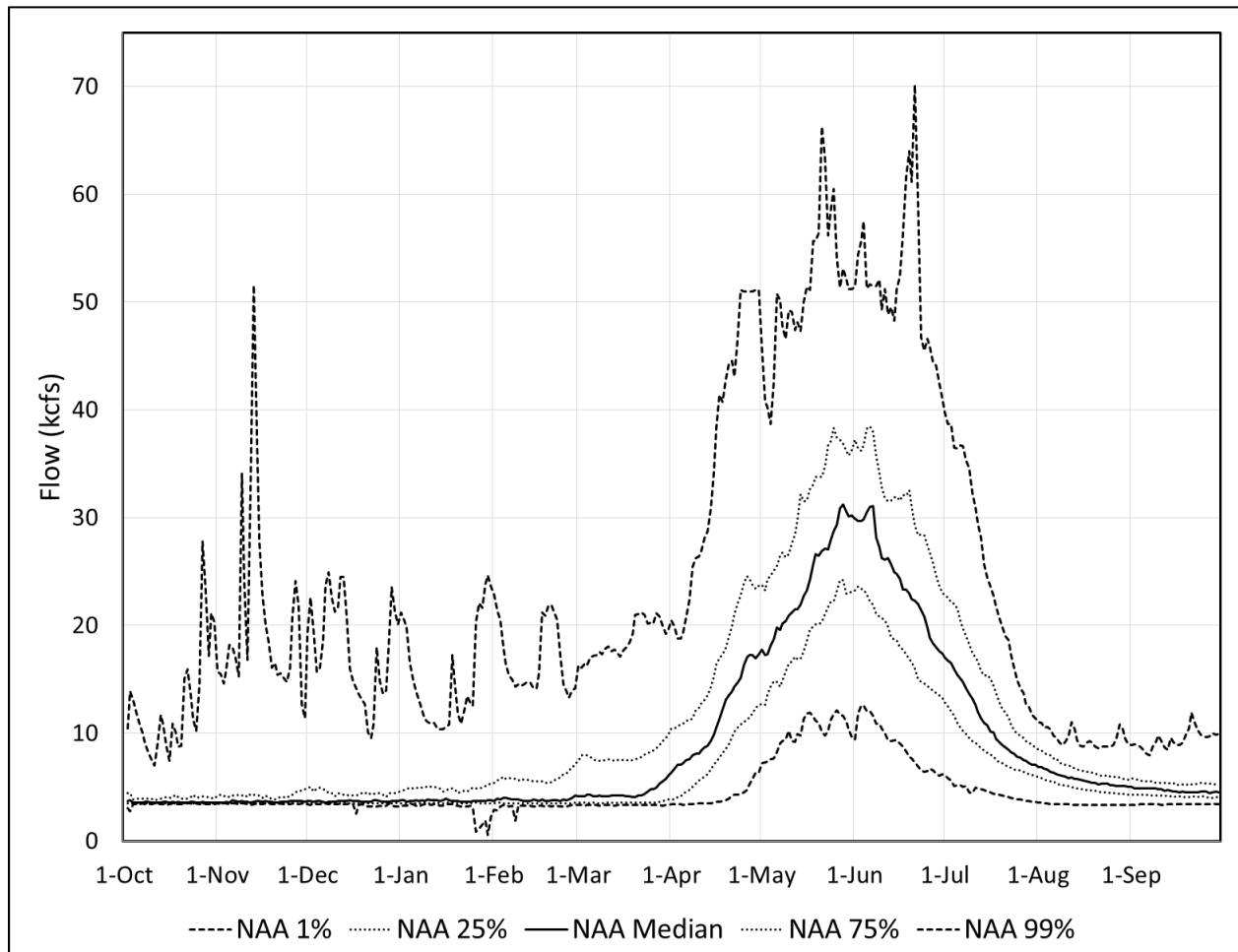
687 The Confederated Salish and Kootenai Tribes of the Flathead Reservation (CSKT) and the
 688 Kootenai Tribe of Idaho have expressed particular interest in any decisions relating to Libby
 689 Dam and Hungry Horse Dam. The CSKT has recognized Treaty rights and interests within and to
 690 waters and lands on the Kootenai River and the Flathead River systems. In CSKT’s Tribal
 691 Perspectives, they assert that “the federal action agencies must consider the significant effects
 692 FCRPS operations will have on tribal waters when proposing Hungry Horse Reservoir
 693 drawdowns to support flow augmentation for anadromous fish, because these flows will pass
 694 through the Flathead Indian Reservation and accordingly, by timing and volume, affect tribal
 695 water quality.” Outflow from October through January is usually less than 3 kcfs, to support
 696 local minimum flows in the South Fork and mainstem Flathead River. The range grows from
 697 February through April to satisfy FRM elevations guided by VarQ. By the beginning of May, the
 698 reservoir usually begins to refill, and outflow generally decreases over the remaining months of
 699 the water year. Hungry Horse Dam will operate for local FRM, reducing outflows, as long as
 700 there is enough space in the reservoir to manage the remaining runoff.

701 From January through April, the reservoir level is adjusted for FRM space requirements. The
 702 amount of reservoir draft or space is dependent on inflow forecasts. The objective of the FRM
 703 season is to provide enough space in the reservoir for system FRM operations in the lower

704 Columbia River, and also to provide local flood protection in the mainstem Flathead River near
705 Columbia Falls, Montana.

706 **Columbia Falls Flow**

707 A summary hydrograph showing the flow at Columbia Falls, Montana, for the No Action
708 Alternative is shown in Figure 3-13. Columbia Falls is on the mainstem of the Flathead River,
709 approximately 11 river miles downstream of Hungry Horse Dam.

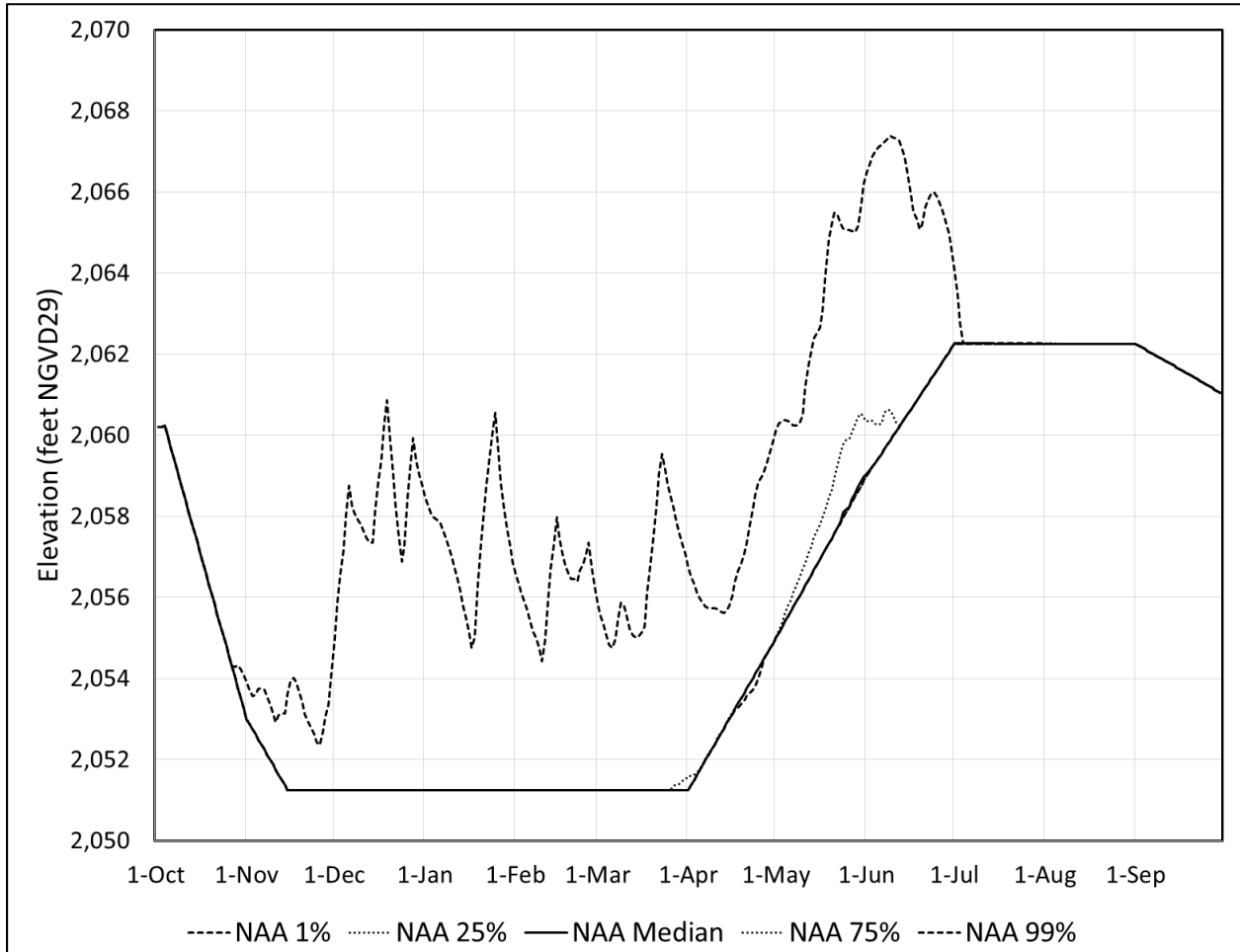


711 **Figure 3-13. Columbia Falls Flow Summary Hydrograph for No Action Alternative**

712 The general pattern throughout most of the water year is similar to that for Hungry Horse Dam
713 outflow. In the late spring and early summer, flows at Columbia Falls are considerably higher
714 than the Hungry Horse Dam outflow, when the spring freshet adds more local runoff to the
715 forks of the Flathead River.

716 **Lake Pend Oreille Elevation**

717 A summary hydrograph showing Lake Pend Oreille elevations for the No Action Alternative is
718 shown in Figure 3-14. For this alternative as well as the MOs evaluated, the Lake Pend Oreille
719 levels presented are for the level at Hope, Idaho.



720

721 **Figure 3-14. Lake Pend Oreille Summary Hydrograph for No Action Alternative**

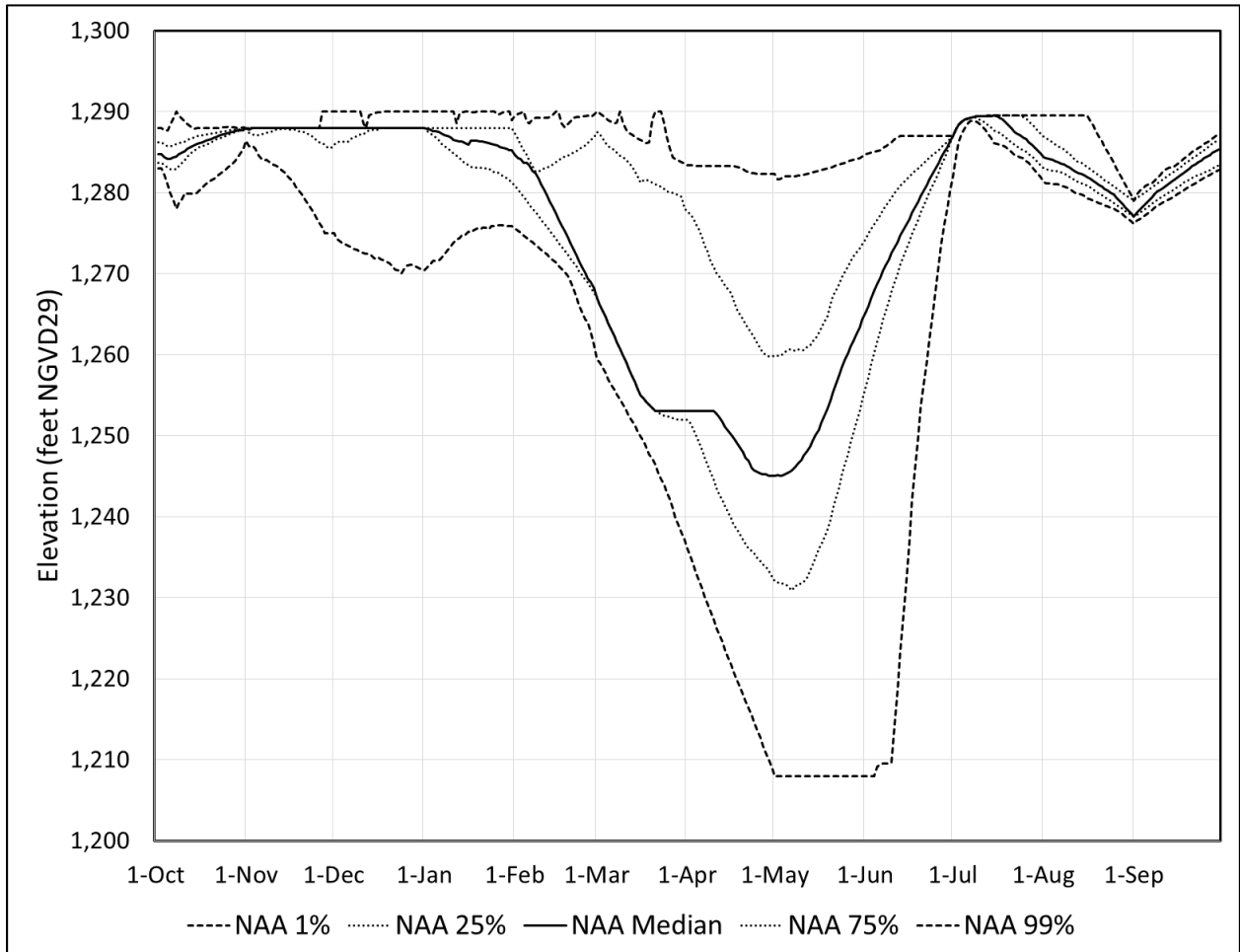
722 In the Lake Pend Oreille elevation summary hydrograph, the 99 percent, 75 percent, median,
723 and 25 percent lines are on top of each other from October through late March, and remain
724 close or identical to each other through the remainder of the water year. The lake level is
725 consistently drawn down each fall and does not have a wide range of elevations in the winter
726 months for the vast majority of water years. Elevated runoff, such as that caused by rain events
727 in the fall or winter months, can drive the lake level up, as reflected in the 1 percent line,
728 representing the maximum elevation. Actual fall and winter lake levels are driven by several
729 factors: system FRM storage, the minimum control elevation related to kokanee salmon, and
730 flexible winter power operations. The highest lake level occurs in the late spring or early
731 summer. The maximum elevation is usually achieved on July 1 and maintained until September
732 1, at which point the lake level begins to drop. The level of Lake Pend Oreille is controlled by

733 Albeni Falls Dam most of the year, with the exception of the late spring/early summer when a
 734 natural riverbed constriction upstream of Albeni Falls Dam limits how much water is able to exit
 735 the lake.

736 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

737 **Lake Roosevelt (Grand Coulee Dam Reservoir) Elevation**

738 The reservoir behind Grand Coulee Dam is called Lake Roosevelt. The summary hydrograph
 739 showing Lake Roosevelt elevations for the No Action Alternative is shown in Figure 3-15.



740
 741 **Figure 3-15. Lake Roosevelt Summary Hydrograph for No Action Alternative**

742 There is little variability in water levels in the fall, as the Grand Coulee Project is operated to fill
 743 from the end of August elevation objective for flow augmentation to 1,283 feet NGDV29 by the
 744 end of September for resident fish purposes. The project continues to fill through October to as
 745 high as 1,288 feet NGVD29 in preparation for winter power operations and to support chum
 746 salmon spawning and incubation below Bonneville Dam. Over the winter months the range of
 747 reservoir water level begins to spread, and this generally continues through about mid-spring.
 748 Different objectives determine reservoir operations during this period: meeting system FRM

749 requirements, generating power, and providing ecosystem flows (managing flows for chum
750 salmon below Bonneville Dam, and for fall Chinook salmon at Vernita Bar). Grand Coulee Dam
751 operates for multiple purposes throughout the year, including FRM, power, and operations for
752 various fish species. The drawdown of the reservoir level that occurs in the winter and early
753 spring months is guided by FRM requirements. The reservoir may also be deeper than the FRM
754 elevation to operate for power, so long as there is an 85 percent chance of being at the spring
755 elevation objective on April 10 to augment spring flows for migrating juvenile salmon and
756 steelhead (this is referred to as a variable draft limit and is based on interpolation between
757 FRM elevations). The time at which the reservoir begins to refill depends on the Columbia River
758 Basin runoff conditions each year, typically beginning in April or May, and reaching at or near
759 full pool in early July. Reservoir levels gradually drop over July and August, as the project is
760 operated to augment flows to assist migrating juvenile anadromous fish in the lower Columbia
761 River.

762 Grand Coulee Dam Outflow

763 A summary hydrograph showing outflow from Grand Coulee Dam for the No Action Alternative
764 is shown in Figure 3-16.

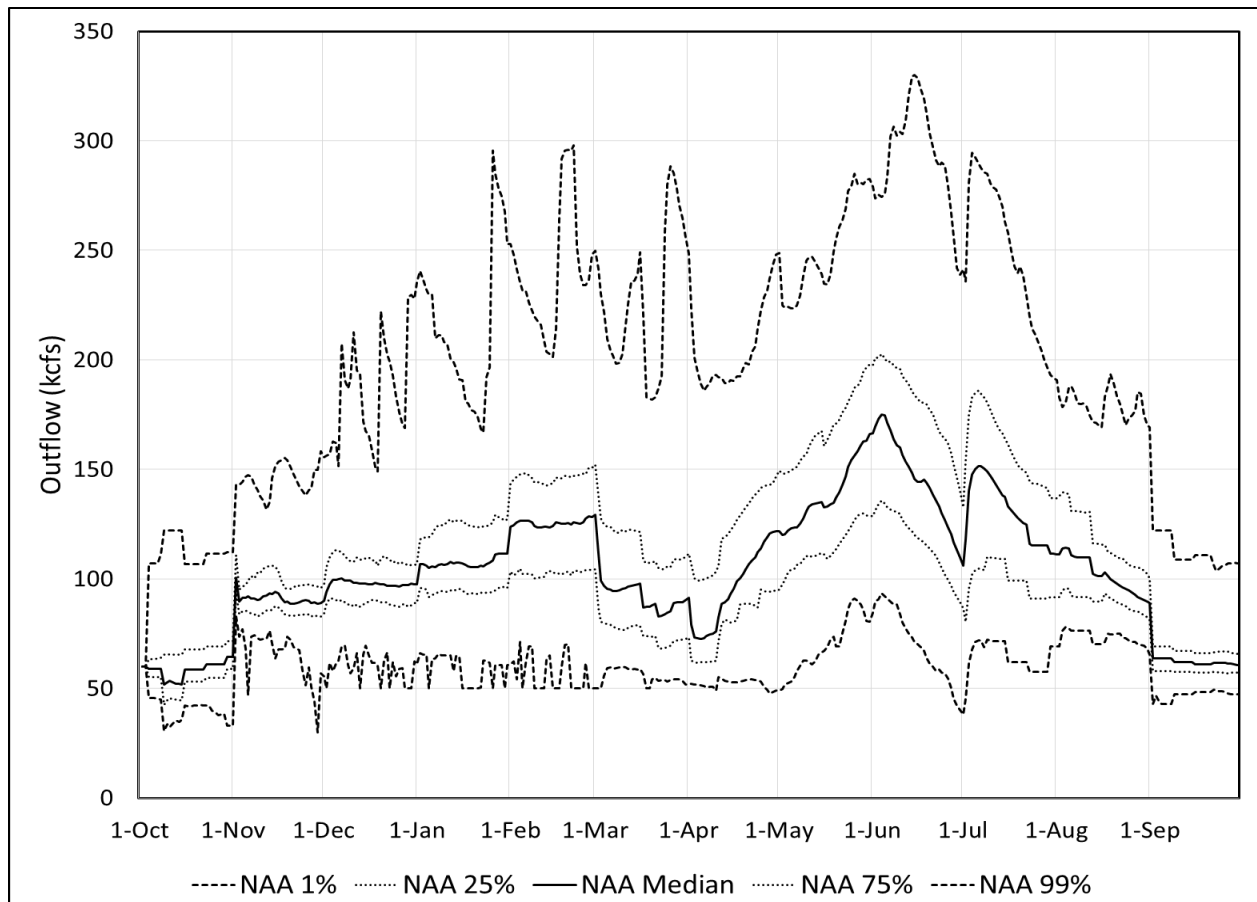


Figure 3-16. Grand Coulee Dam Outflow Summary Hydrograph for No Action Alternative

767 The months with highest flows are generally May and June, and the months with the lowest
768 flows are generally September and October. As a multi-purpose project, there are multiple
769 reasons for the releases at Grand Coulee Dam throughout the water year, which are broadly
770 categorized in Figure 3-7. One of the purposes not portrayed in Figure 3-7, water supply, does
771 not impact reservoir elevations but does impact outflows. Water is pumped out of Lake
772 Roosevelt at Grand Coulee Dam to Banks Lake, which directly impacts the flows downstream.
773 Further information on how Grand Coulee Dam operations are modeled is provided in the H&H
774 Appendix (Appendix B, Part 3, *HEC-ResSim/WAT Documentation*).

775 **Middle Columbia River below Grand Coulee Dam**

776 Chief Joseph Dam is a run-of-river project located downstream of Grand Coulee Dam. The
777 elevation of the reservoir behind Chief Joseph Dam, known as Lake Rufus Woods, is fairly
778 consistent through the entire calendar year, and outflows closely match those from Grand
779 Coulee Dam. The reservoir elevation at Chief Joseph Dam ranges between 950.0 and 956.0 feet
780 NGVD29. Table 3-6 shows the median values of monthly average flows at locations in the
781 middle Columbia River for the No Action Alternative.

782 **Table 3-6. Middle Columbia River Monthly Average Flows (kcfs) for No Action Alternative**

Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lake Roosevelt Inflow ^{1/}	64	82	92	95	100	65	69	131	166	133	98	75
Grand Coulee	59	91	97	108	126	93	97	138	150	134	102	63
Chief Joseph	58	91	96	108	127	94	98	139	150	135	103	63
Wells	59	93	98	110	129	95	101	150	163	141	105	65
Priest Rapids	60	96	102	115	133	100	108	162	178	147	108	68

783 1/ "Lake Roosevelt inflow" is the term used for flow in the Columbia River just downstream of the U.S.-Canada
784 border (about 151 river miles upstream of Grand Coulee Dam).

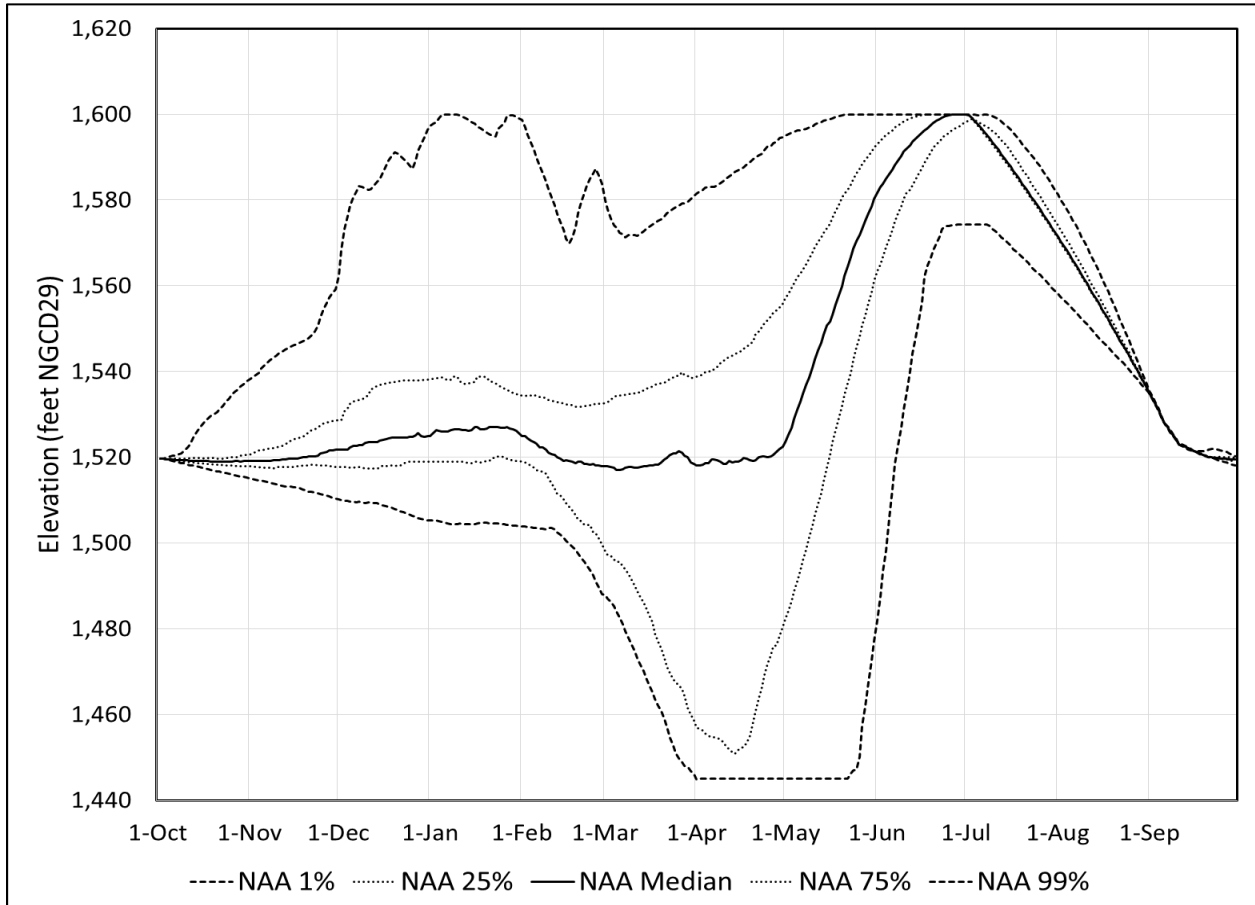
785 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
786 **HARBOR DAMS**

787 **Dworshak Dam**

788 A summary hydrograph showing Dworshak Reservoir elevations for the No Action Alternative is
789 shown in Figure 3-17.

790 The water year generally begins with a reservoir elevation of about 1,520 feet NGVD29.
791 Although there is a wide spread between the 99 percent chance and 1 percent chance
792 exceedance lines for much of the year, the typical seasonal pattern is best understood from
793 viewing the span between the 75 percent chance and 25 percent chance exceedance lines.
794 From October through January, the water level in the reservoir can increase or decrease. The
795 range of possible reservoir elevations widens further in the subsequent winter months, lasting
796 into the early spring. The reservoir level in the winter and early spring months is guided by FRM
797 requirements, and also by minimum outflows. The reservoir begins refilling in the spring and
798 usually reaches its full pool elevation of 1,600 feet NGVD29 by July 1. The reservoir level is
799 drawn down over the summer months to provide cool water to the Snake River, provide flows

800 for salmon migration, and meet the flows per the agreement between the United States and
801 the Nez Perce Tribe, ending at an elevation of 1,520 feet NGVD29 on September 30.
802 Throughout the entire water year, the reservoir levels behind Dworshak Dam are the result of
803 the operations for multiple purposes, broadly categorized in Figure 3-7. Further information on
804 how Dworshak Dam operations are modeled is provided in the H&H Appendix (Appendix B, Part
805 3, *HEC-ResSim/WAT Documentation*).



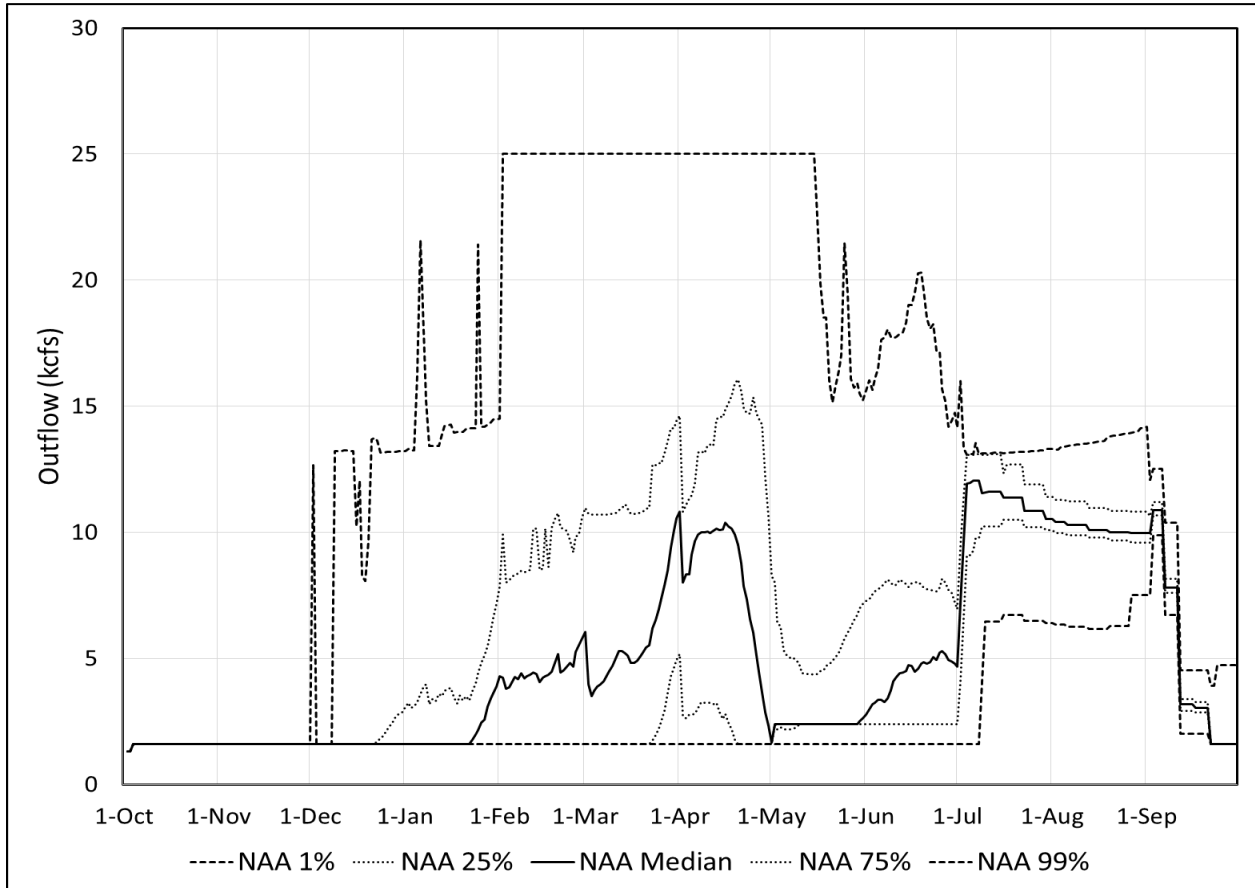
806
807 **Figure 3-17. Dworshak Reservoir Summary Hydrograph for No Action Alternative**

808 **Dworshak Dam Outflow**

809 A summary hydrograph showing outflow from Dworshak Dam for the No Action Alternative is
810 shown in Figure 3-18.

811 Flows usually remain low from October through December. The flow in the winter months is
812 generally higher than the fall, as the reservoir is drafted for FRM purposes. Outflow is generally
813 reduced by May so that the reservoir can refill by the beginning of July. In July and August,
814 outflow, typically ranging from 10 to 13 kcfs, is released for flow augmentation and water
815 temperature moderation in the lower Snake River Basin. Releases during the month of
816 September, while the reservoir is between 1,535 and 1,520 feet NGVD29, are made to provide
817 water for salmon migration and to meet flows per the Agreement between the United States

818 and the Nez Perce Tribe. The release is shaped to gradually reduce flows to minimum outflow
819 of 1.6 kcfs over the course of the month.



820
821 **Figure 3-18. Dworshak Dam Outflow Summary Hydrograph for No Action Alternative**

822 **Clearwater River below Dworshak Dam and the Lower Snake River**

823 Water released from Dworshak Dam passes through the four lower Snake River dams that
824 operate as run-of-river projects: Lower Granite Dam, Little Goose Dam, Lower Monumental
825 Dam, and Ice Harbor Dam. For the No Action Alternative, the lower Snake River dams are
826 operated to their MOP range from April 3 through August 31; otherwise there is little change in
827 their reservoir elevations through the calendar year. Table 3-7 shows the median values of
828 monthly average flows at locations in the lower Snake River Basin for the No Action Alternative.
829 Outflows from Dworshak Dam contribute to flows in the lower Snake River but are a smaller
830 portion of the total flow than releases from the Hells Canyon Complex during fall, winter, and
831 spring.

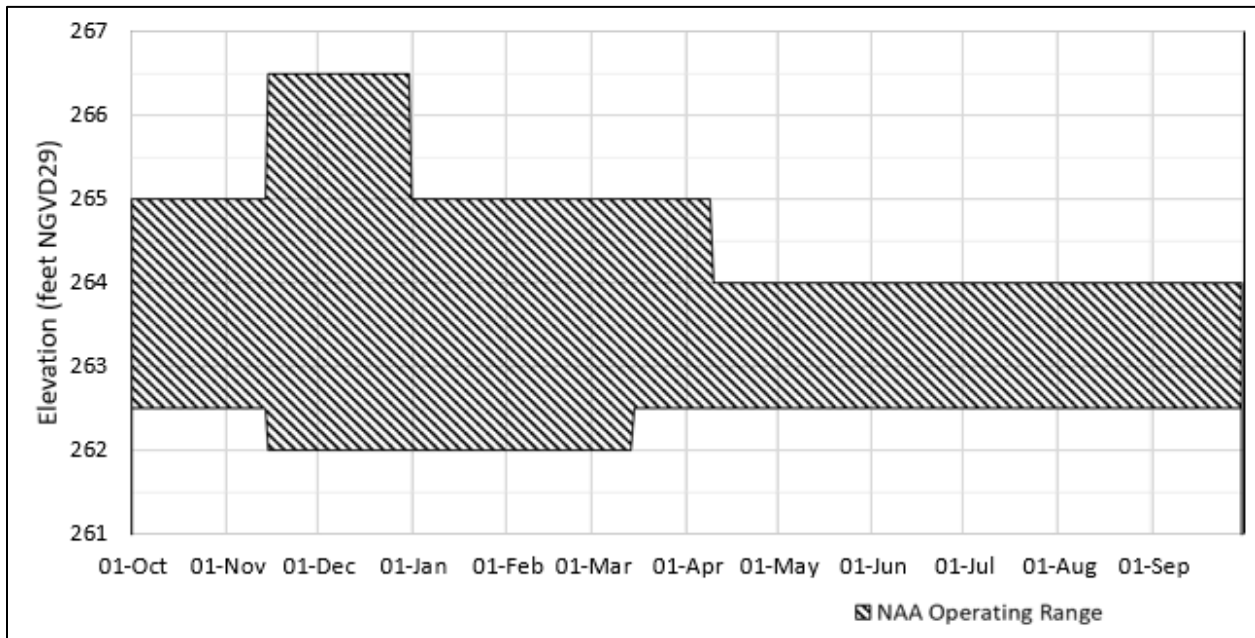
832 **Table 3-7. Lower Snake Basin Monthly Average Flows (kcfs) for No Action Alternative**

Location												
Dworshak	1.6	1.6	1.6	2.1	5.1	6.2	9.6	3.5	4.8	10.7	10.2	5.0
Spalding, ID	3.4	4.5	4.7	5.9	10.6	15.5	26.8	33.4	28.7	17.0	12.2	6.5
Snake + Clearwater	19.7	20.9	23.9	28.3	39.0	47.2	69.7	94.4	96.4	47.9	29.2	22.6
Lower Granite	19.8	21.0	23.7	28.4	39.3	48.0	71.8	95.6	97.4	48.6	29.1	22.5
Ice Harbor	20.2	21.4	24.5	29.4	42.0	50.7	73.0	95.4	97.2	48.4	28.1	21.2

833 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

834 **Lower Columbia River Reservoirs**

835 McNary, John Day, The Dalles, and Bonneville Dams are referred to as the four lower Columbia
 836 River dams. They generally operate as run-of-river projects. For the No Action Alternative, John
 837 Day Dam is modeled operating to its MIP level from April 10 through September 30 but may
 838 provide some FRM space during winter or spring floods. Otherwise, there is little change in the
 839 reservoir elevations through the calendar year for any of the four lower Columbia River dams.
 840 The operating range for John Day Dam is shown in Figure 3-19.



841
 842 **Figure 3-19. John Day Dam Operating Range for No Action Alternative**

843 Note: John Day may be operated between 257 feet and 268 feet NGVD29 for FRM purposes. These limits are not
 844 shown on this figure in order to show greater detail in the vertical scale.

845 **Lower Columbia River Flows**

846 Because McNary Dam is a run-of-river project, McNary Dam outflow is equivalent to the
 847 combined flow of the Columbia River through Region B and the Snake River through Region C. A
 848 summary hydrograph showing outflow from McNary Dam for the No Action Alternative is
 849 shown in Figure 3-20. Flows are generally highest in May and June.

850 Outflow patterns from McNary Dam generally persist through the three dams downstream,
851 though there are tributaries that join the Columbia River downstream of McNary Dam and
852 some shaping of flows by John Day Dam occurs during winter flood operations. On an hourly
853 basis, river flows can increase or decrease dramatically for hydropower generation. Table 3-8
854 shows the median values of monthly average flows at locations along the lower Columbia River
855 for the No Action Alternative.

856 **Table 3-8. Lower Columbia River Monthly Average Flows (kcfs) for No Action Alternative**

Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Columbia + Snake	83	122	134	151	181	157	188	260	288	199	140	91
McNary	85	124	136	154	182	159	192	260	285	198	141	93
John Day	85	125	140	156	185	165	198	267	288	197	141	93
The Dalles	90	130	146	163	192	172	206	273	293	202	146	97
Bonneville	91	135	152	170	199	179	213	275	296	204	149	99
Columbia + Willamette	108	178	225	252	267	233	260	314	319	216	159	111
Columbia + Cowlitz	115	196	257	282	295	255	283	334	336	226	165	117

857 **SUMMARY OF EFFECTS**

858 Under the No Action Alternative, all CRS projects are modeled to represent the current
859 operating rules and constraints. The eight run-of-river dams (Ice Harbor, Lower Monumental,
860 Little Goose, Lower Granite, Chief Joseph, Bonneville, The Dalles, and McNary) are each
861 operated with water levels that are within a seasonal elevation range. The hourly, daily, and
862 weekly water level will vary within that range to meet multiple operating purposes. While this
863 hourly and daily fluctuation in water level and reservoir release can affect river flow, it does not
864 result in major seasonal shifts of river flow and the shape of the flow hydrograph. Some water
865 is diverted from these reservoirs to meet water supply needs.

866 Five of the storage dams (Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak) are
867 operated in, generally, a seasonal cycle and do affect the shape of the hydrograph. The cycle
868 starts in the early winter with each reservoir slowly lowering its water level (referred to as
869 drawdown) to meet many purposes: to generate hydropower, to allow capture of winter rain
870 events, to prepare to capture forecast spring snowmelt runoff, and to provide water for fish
871 species. The amount that reservoir water levels are lowered depends on many factors including
872 existing temperature and precipitation as well as on forecasts (predictions) of the amount of
873 snowmelt that is expected later that year. Storage reservoirs usually reach their lowest level in
874 late March or April. Once snow begins to melt and flow into the rivers in late spring and early
875 summer, the reservoirs begin to capture the snowmelt runoff and increase their water level.
876 They do this in order to prevent flooding as well as to fill the reservoirs for summer. In the late
877 spring and early summer, flow in all rivers in the basin is usually at its highest due to natural
878 snowmelt. As spring runoff begins to decrease, reservoir water levels increase to close to full
879 and remain there for varying periods of time after which they slowly begin to lower their water
880 elevation and release water to provide higher flows in the river than would occur naturally in
881 the late summer into early fall. Some water is diverted from these reservoirs to meet water
882 supply needs. Towards the end of fall, the operating cycle of storage reservoirs begins again.

883 John Day Dam is a storage reservoir but it is often operated more like a run-of-river project,
884 within seasonal water elevation ranges. It can, however, lower its water surface elevation,
885 when necessary, to prepare to capture water from winter or spring floods.

886 **3.2.4.4 Multiple Objective Alternative 1**

887 As the effects of MO1 are presented, they will be displayed along with the No Action
888 Alternative to illuminate the timing and magnitude of differences in water conditions between
889 it and the No Action Alternative. The operational measure (or measures) from MO1 which
890 would result in changes from the No Action Alternative are identified to the extent that this is
891 possible based on experience with system operation and hydroregulation modeling. However,
892 because the measures were combined into an alternative that was then modeled, isolating the
893 effect a single measure would have is not possible in many cases. Further supporting details are
894 included in the H&H Appendix (Appendix B, Part 1, *H&H Data Analysis*).

895 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

896 **Lake Kocanusa (Libby Dam Reservoir) Elevation**

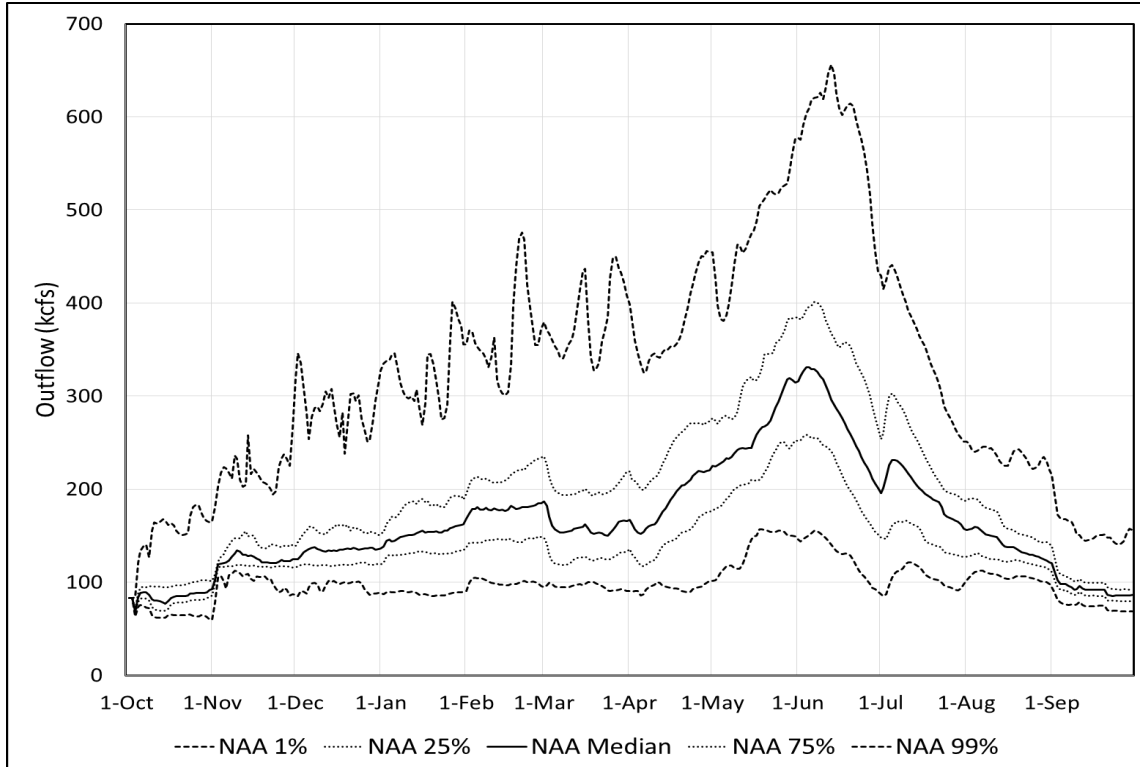
897 Under MO1, the *Modified Draft at Libby*, *December Libby Target Elevation*, and *Sliding Scale at*
898 *Libby and Hungry Horse* measures would have a direct effect on Libby Dam operations.

899 Reservoir water levels in Lake Kocanusa would differ from the No Action Alternative, as shown
900 in Figure 3-21.

901 MO1 would have the same end-of-November target reservoir elevation as the No Action
902 Alternative. However, over the course of December, the reservoir elevations for MO1 would
903 differ from those under the No Action Alternative due to the *December Libby Target Elevation*
904 measure, which calls for an end-of-December target elevation of 2,420 feet NGVD29 in all
905 years. Most of the time, this would make the reservoir elevation on December 31 higher than
906 the No Action Alternative; however, in about the driest 30 percent of forecast years at Libby
907 Dam (those forecasted to have an April to August runoff volume of 5.67 Maf or less), the
908 reservoir elevation on December 31 would be lower than the No Action Alternative.

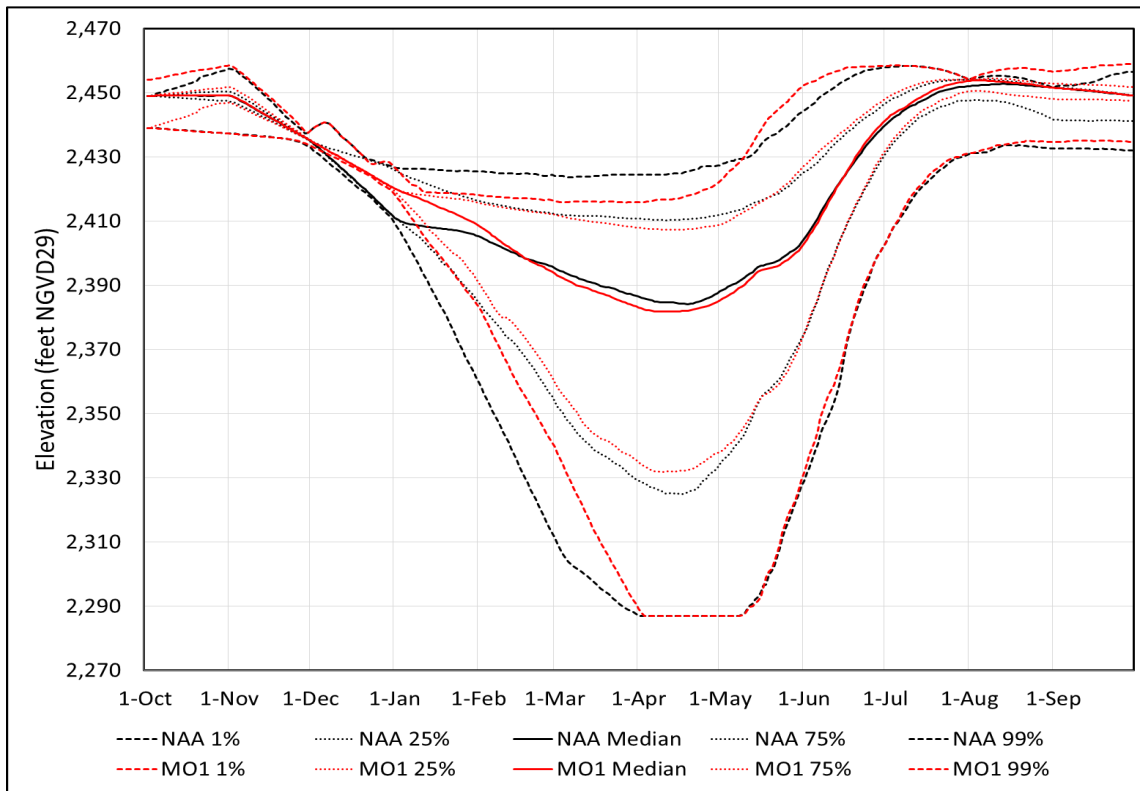
909 From December 31 through mid-February, reservoir levels would generally be higher under
910 MO1 than they would be for the No Action Alternative, though for the driest forecast years, the
911 reservoir would be lower (shown in Figure 3-22).

912 The *Modified Draft at Libby* measure would begin influencing reservoir elevations after
913 December 31, and its effects are best understood by looking at the spring, when the lowest
914 reservoir elevation typically occurs. While the *December Libby Target Elevation* measure
915 generally delays the lowering of the reservoir, it is the *Modified Draft at Libby* measure that
916 causes the spring reservoir elevation to be lower than the No Action Alternative when the
917 seasonal water supply forecast is less than 6.9 Maf at Libby Dam. This is not the case for all
918 years, though, as demonstrated by the 75 percent exceedance lines for MO1 and the No Action
919 Alternative. There, the case is the opposite; the reservoir elevation under MO1 would be higher
920 than that for the No Action Alternative through about the first half of spring.



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 922

Figure 3-20. McNary Dam Outflow Summary Hydrograph for No Action Alternative



923
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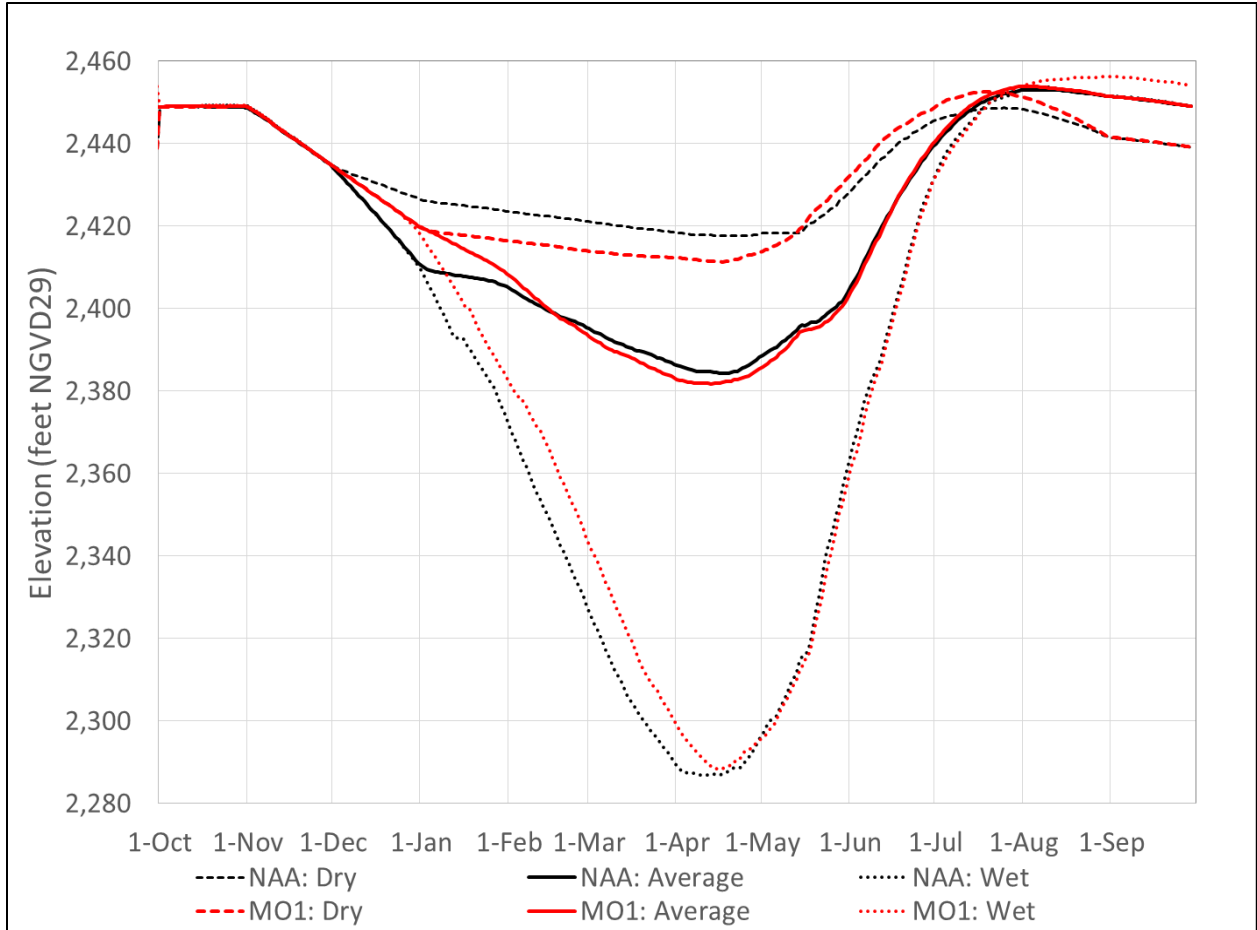
Figure 3-21. Lake Kocanusa Summary Hydrograph for Multiple Objective Alternative 1

925 The *Modified Draft at Libby* measure would result in a general increased likelihood of reservoir
926 refill in all water year types. For MO1, there would be a 51 percent chance of the reservoir
927 reaching elevation 2,454 feet NGVD29 or higher (within 5 feet of the full pool elevation of 2,459
928 feet NGVD29) by July 31, as compared to a 39 percent chance for the No Action Alternative. The
929 peak reservoir elevation would usually be achieved in July or early August.

930 During the months of August and September, the reservoir elevation for MO1 would generally
931 be about one to four feet higher than for the No Action Alternative. The reason for this is the
932 *Modified Draft at Libby* measure, which tends to increase the peak refill elevation, and the
933 *Sliding Scale at Libby and Hungry Horse* measure which calls for a sliding scale end-of-
934 September target elevation that would be dependent on the Libby Dam water supply forecast,
935 rather than the system-wide water supply forecast at The Dalles. The *Sliding Scale at Libby and*
936 *Hungry Horse* measure targets a higher elevation than the No Action Alternative in the wettest
937 25 percent of years.

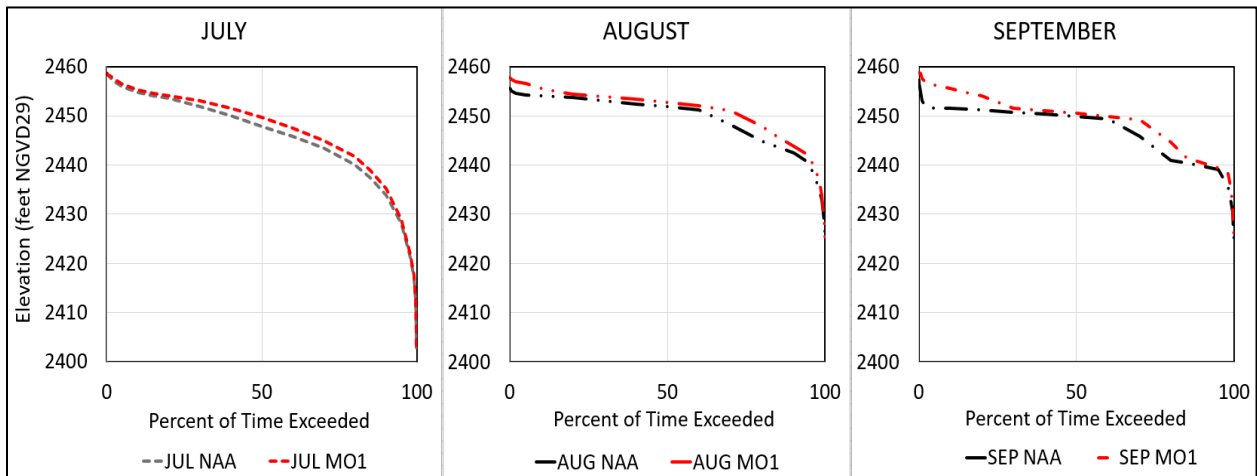
938 Reservoir water levels in Lake Koochanusa under MO1 would differ from the No Action
939 Alternative to varying extents, depending on the water year type. Median hydrographs of the
940 reservoir level for dry, average, and wet years are shown in Figure 3-22.

941 Finally, the three panels in Figure 3-23 show monthly elevation duration curves for July, August,
942 and September, respectively. The curve for MO1 is plotted along with the curve for the No
943 Action Alternative in each month, showing that the reservoir level would be higher in each of
944 the 3 months for MO1. In July, this is attributable to the *Modified Draft at Libby* measure, which
945 tends to increase the peak refill elevation. In August the higher reservoir levels are attributable
946 to a combination of the *Modified Draft at Libby* and *Sliding Scale at Libby and Hungry Horse*
947 measures. In September, the higher reservoir levels are attributable to the *Sliding Scale at Libby*
948 *and Hungry Horse* measure, which has fewer years drafting to 2,439 feet NGVD29 than the No
949 Action Alternative (due to the change in forecast location), and the wettest years only needing
950 a draft to 2,454 feet NGVD29.



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 953

Figure 3-22. Lake Kocanusa Water Year Type Hydrographs for Multiple Objective Alternative 1

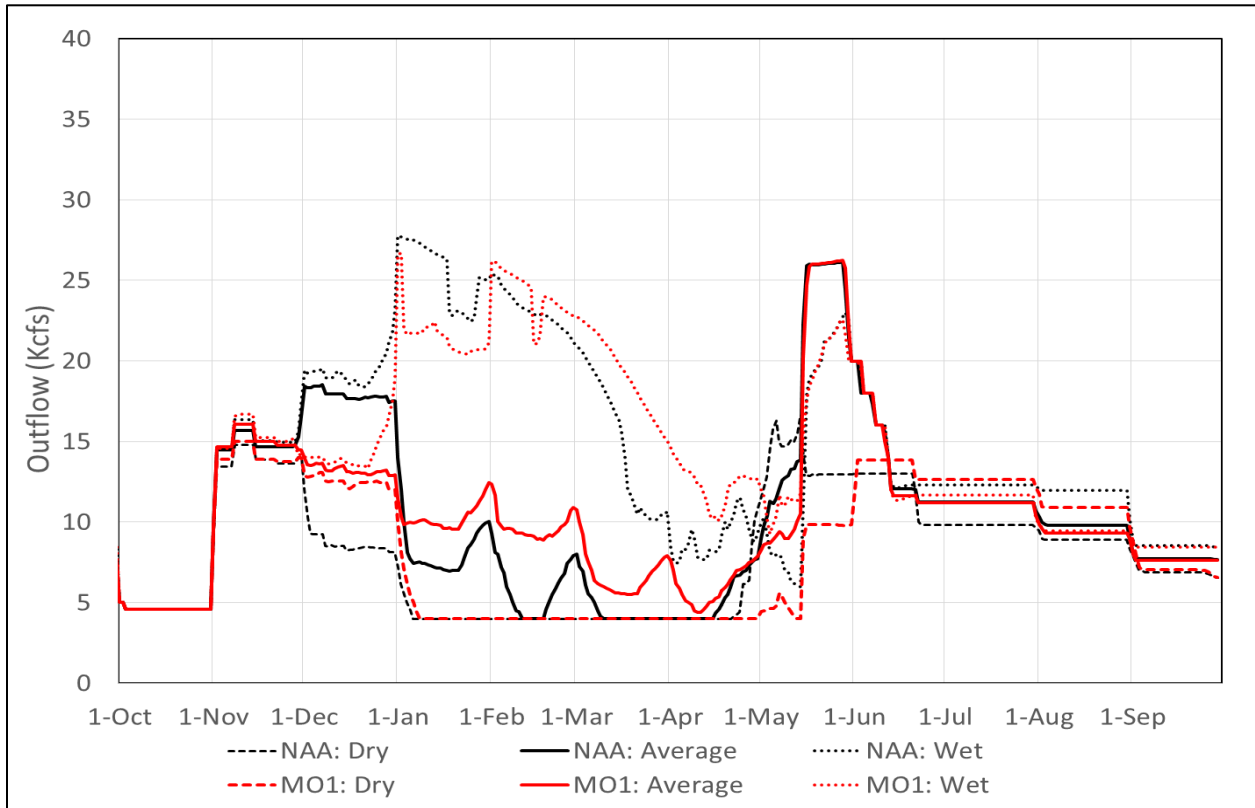


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Figure 3-23. Lake Kocanusa Summer Elevations for Multiple Objective Alternative 1

956 **Libby Dam Outflow**

957 Under MO1, the *Modified Draft at Libby*, *December Libby Target Elevation*, and *Sliding Scale at*
 958 *Libby and Hungry Horse* measures would have a direct effect on Libby Dam outflows. The
 959 outflows would differ from the No Action Alternative in a variety of ways throughout the year.
 960 Figure 3-24 shows median hydrographs for Libby Dam outflow in dry, average, and wet years.



961
 962 **Figure 3-24. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 963 **Alternative 1**

964 The change in average monthly outflow throughout the water year is presented in Table 3-9. A
 965 range of exceedance percentiles is presented because in some months, the direction and
 966 magnitude of change varies depending on whether one looks at flows more likely to be
 967 exceeded (99 percent exceedance, 75 percent exceedance) or flows less likely to be exceeded
 968 (25 percent exceedance, 1 percent exceedance).

969 Average outflow from Libby Dam under MO1 would differ from the No Action Alternative:

- 970 • In December, the median value of the monthly average outflow would decrease by 4.4 kcfs
 971 due to the *December Libby Target Elevation* measure. The flows at the 25 percent and 1
 972 percent exceedance levels (higher flows) would also decrease, while the flows at the 75
 973 percent and 99 percent exceedance levels would increase.

- 974 • In January, February, and March the median value of the monthly average outflow would
975 increase by 1.7, 3.3, and 1.6 kcfs, respectively. These outflow increases are caused by the
976 reservoir being lowered at a faster rate under MO1 than the No Action Alternative for many
977 years, caused by the *December Libby Target Elevation* measure as well as the *Modified Draft*
978 *at Libby* measure.
- 979 • In April and May, the median value of the monthly average outflow would decrease by 0.6
980 kcfs and 0.7 kcfs, respectively. However, Figure 3-24 shows that outflows would be higher in
981 April and May for wet years and lower for dry years. These changes are related to the VarQ
982 update that is part of the *Modified Draft at Libby* measure that would account for future
983 volume releases and refill the reservoir more aggressively.
- 984 • In June and July, the median value of the monthly average outflows would be similar to the
985 No Action Alternative. However, in late June and July of dry years, the outflow would
986 increase by about 3 kcfs under MO1 from that in the No Action Alternative because under
987 MO1, there would be less space to fill due to more aggressive planned refill of the reservoir.
- 988 • In August and September, the median value of the monthly average outflow would
989 decrease by 0.7 and 0.2 kcfs, respectively. The *Sliding Scale at Libby and Hungry Horse*
990 measure, which calls for a sliding scale end-of-September target elevation based on the
991 Libby Dam water supply forecast and a higher elevation target in the wettest 25 percent of
992 years, is the primary cause of these changes.

993 **Table 3-9. Libby Dam Monthly Average Outflow for Multiple Objective Alternative 1 (as**
994 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	4.9	23.5	22.0	27.1	25.8	23.0	20.8	22.7	22.6	22.9	17.8	12.0
		25%	4.7	16.2	18.9	18.3	20.0	12.2	9.9	19.2	17.1	14.3	12.1	8.8
		50%	4.7	14.3	17.7	8.8	6.3	5.5	7.0	16.4	14.2	11.5	10.3	7.9
		75%	4.7	12.0	9.9	5.6	4.0	4.0	4.4	14.0	12.9	9.0	9.0	6.8
		99%	4.7	7.0	8.2	4.3	4.0	4.0	4.0	11.6	8.8	7.1	7.1	6.0
MO1	Change (kcfs)	1%	0.6	0.4	-1.8	-1.4	0.8	0.2	-1.1	-1.0	0.9	0.3	-2.3	0.5
		25%	0.0	1.2	-4.9	1.1	1.5	3.2	0.4	-0.9	-0.6	0.0	-0.8	-0.1
		50%	0.0	0.2	-4.4	1.7	3.3	1.6	-0.6	-0.7	-0.3	0.0	-0.7	-0.2
		75%	0.0	-0.4	2.7	0.2	0.5	0.2	0.1	-2.2	-0.2	0.0	0.0	-0.2
		99%	0.0	-0.4	3.5	0.5	0.0	0.0	0.0	-5.5	0.9	0.7	0.7	0.1
	Percent change	1%	12%	2%	-8%	-5%	3%	1%	-5%	-4%	4%	1%	-13%	4%
		25%	0%	7%	-26%	6%	7%	26%	4%	-5%	-3%	0%	-7%	-1%
		50%	0%	2%	-25%	19%	52%	29%	-8%	-4%	-2%	0%	-7%	-3%
		75%	0%	-4%	27%	3%	12%	4%	1%	-16%	-1%	0%	0%	-2%
		99%	0%	-5%	43%	12%	0%	0%	0%	-47%	10%	10%	9%	1%

995 Note: Ave. = average; mo. = monthly. Values for the No Action Alternative are shaded gray. Orange shading
996 denotes MO1 flows lower than the No Action Alternative flows; green shading denotes MO1 flows higher than the
997 No Action Alternative flows.

998 **Bonniers Ferry Flow**

999 Under MO1, the *Modified Draft at Libby, December Libby Target Elevation, and Sliding Scale at*
1000 *Libby and Hungry Horse* measures would affect flows at Bonners Ferry. In general, the flows
1001 would differ from the No Action Alternative in much the same way as at Libby Dam, and for the
1002 same reasons. The change in average monthly flow at Bonners Ferry throughout the water year
1003 is presented in Table 3-10.

1004 **Table 3-10. Bonners Ferry Monthly Average Flow for Multiple Objective Alternative 1 (as**
1005 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	9.0	26.6	29.2	31.3	29.7	27.5	30.4	40.8	40.7	27.2	19.0	13.3
		25%	6.1	18.1	20.7	21.0	23.2	15.3	19.4	34.3	27.8	17.3	13.3	9.7
		50%	5.6	15.4	18.9	10.4	8.5	8.4	14.6	31.1	23.8	14.6	11.4	8.6
		75%	5.4	13.0	11.4	6.5	5.1	5.9	10.2	27.6	20.3	11.8	9.9	7.4
		99%	5.1	7.7	9.0	5.1	4.5	4.9	7.0	18.3	12.6	9.0	8.1	6.7
MO1	Change (kcfs)	1%	0.5	0.4	-1.5	-2.6	1.3	2.7	0.4	0.5	1.0	-0.2	-2.6	1.0
		25%	0.0	1.1	-4.9	0.3	0.4	3.8	0.0	-0.4	-0.5	-0.2	-0.7	0.0
		50%	0.0	0.3	-4.3	1.7	3.1	1.5	-0.1	-0.9	-0.2	0.0	-0.7	-0.3
		75%	0.0	-0.2	2.2	0.4	0.6	0.5	0.1	-3.7	0.1	0.3	0.0	-0.1
		99%	0.0	-0.4	3.4	0.5	0.1	0.0	0.0	-4.8	0.3	0.1	0.4	0.0
	Percent change	1%	6%	1%	-5%	-8%	4%	10%	1%	1%	2%	-1%	-14%	8%
		25%	0%	6%	-23%	1%	2%	25%	0%	-1%	-2%	-1%	-5%	0%
		50%	0%	2%	-23%	17%	36%	18%	-1%	-3%	-1%	0%	-6%	-3%
		75%	0%	-2%	19%	6%	12%	9%	1%	-13%	0%	2%	0%	-1%
		99%	0%	-5%	38%	10%	2%	0%	0%	-26%	2%	1%	4%	-1%

1006 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO1 flows lower than the No
1007 Action Alternative flows; green shading denotes MO1 flows higher than the No Action Alternative flows.

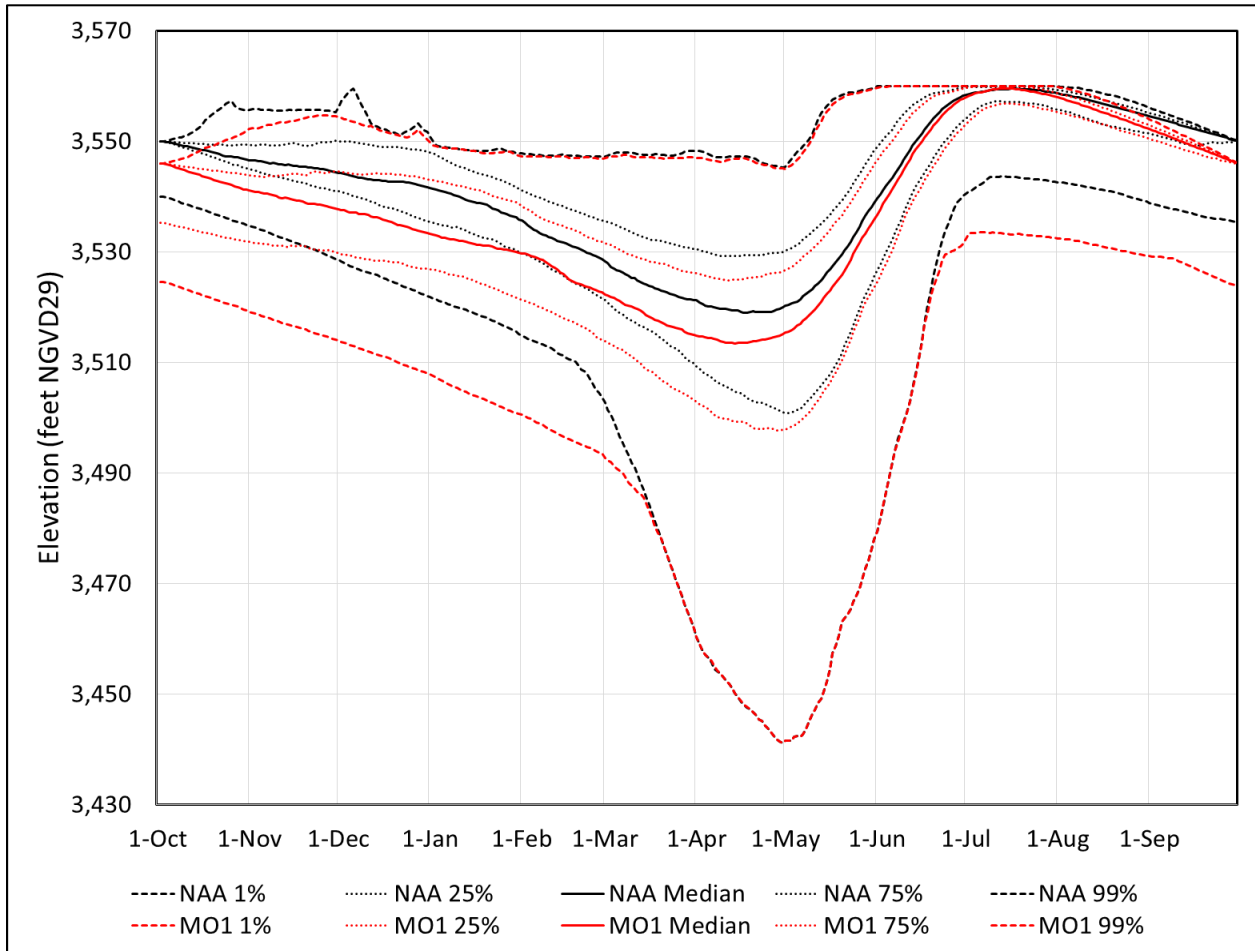
1008 **Hungry Horse Reservoir Elevation**

1009 Under MO1, the *Hungry Horse Additional Water Supply and Sliding Scale at Libby and Hungry*
1010 *Horse* measures would have a direct effect on Hungry Horse Dam operations.

1011 Reservoir water levels would differ from the No Action Alternative, as shown in Figure 3-25.

1012 The water year would begin with the reservoir levels for MO1 being lower than those for the
1013 No Action Alternative. This is because the operations associated with the *Hungry Horse*
1014 *Additional Water Supply* measure would leave the reservoir at a lower elevation on September
1015 30 than under the No Action Alternative, and the condition would carry over to the following
1016 water year. It should be noted that when MO1 was modeled, the initial Hungry Horse Reservoir
1017 levels at the start of each water year were erroneously set lower than intended. This
1018 initialization error had little effect downstream from Hungry Horse Dam. Hungry Horse Dam’s
1019 modeled releases were up to 1 kcfs lower than they should have been, but by the time flow

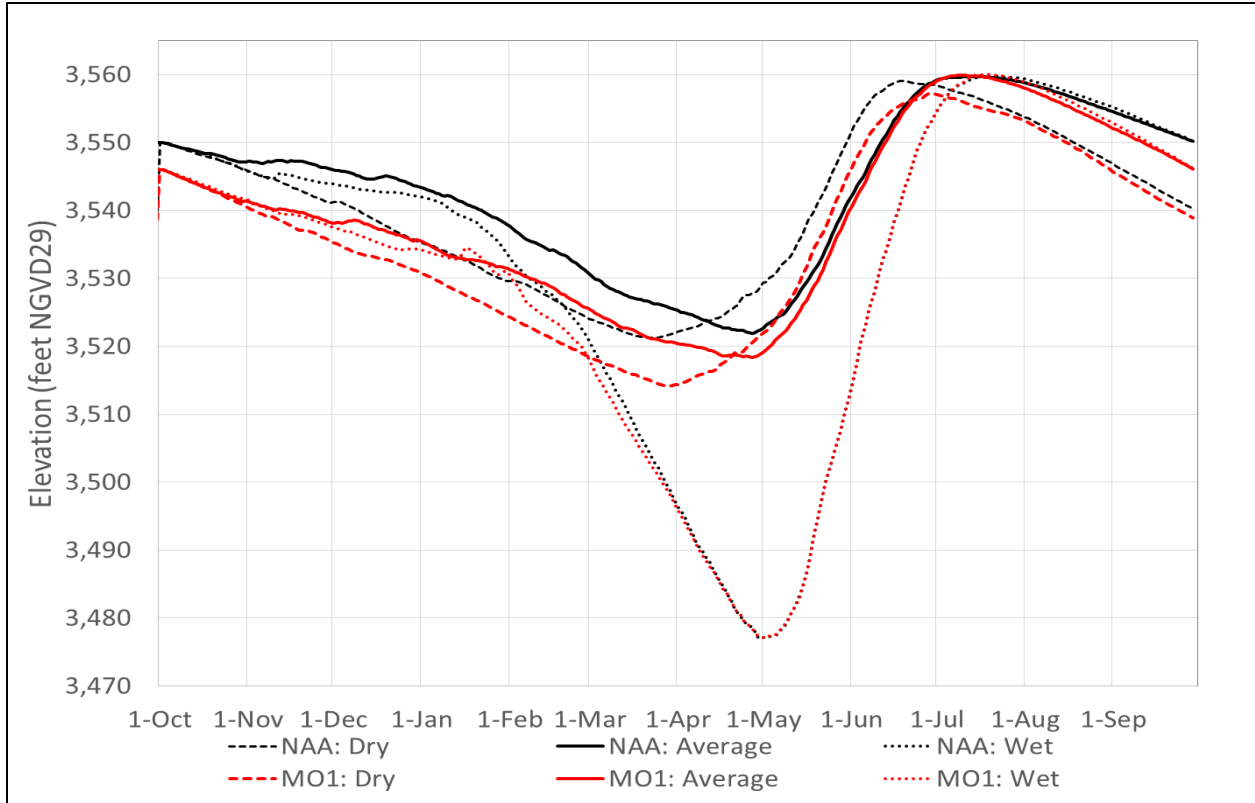
1020 reaches Flathead Lake, the MO1 results have little error. A subsequent sensitivity analysis
 1021 revealed that this initialization error primarily affected results in the fall and winter. In the
 1022 summary hydrograph shown in Figure 3-25, the median and higher elevations should have
 1023 water levels 1 to 3 feet higher than shown from October through May. Below the median, the
 1024 results should be 5 to 10 feet higher from October through February.



1025
 1026 **Figure 3-25. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative**
 1027 **1**

1028 Overall, reservoir elevations under MO1 would be lower than for the No Action Alternative. At
 1029 the median level, reservoir elevations would be about 4 feet lower in November through April
 1030 and 0 to 2 feet lower in May through August. By the end of September, reservoir levels under
 1031 MO1 would typically be 4 feet lower than the No Action Alternative. The *Sliding Scale at Libby*
 1032 *and Hungry Horse* measure results in reducing the draft requirements in some years, by setting
 1033 a higher elevation target for summer flow augmentation than the No Action Alternative.

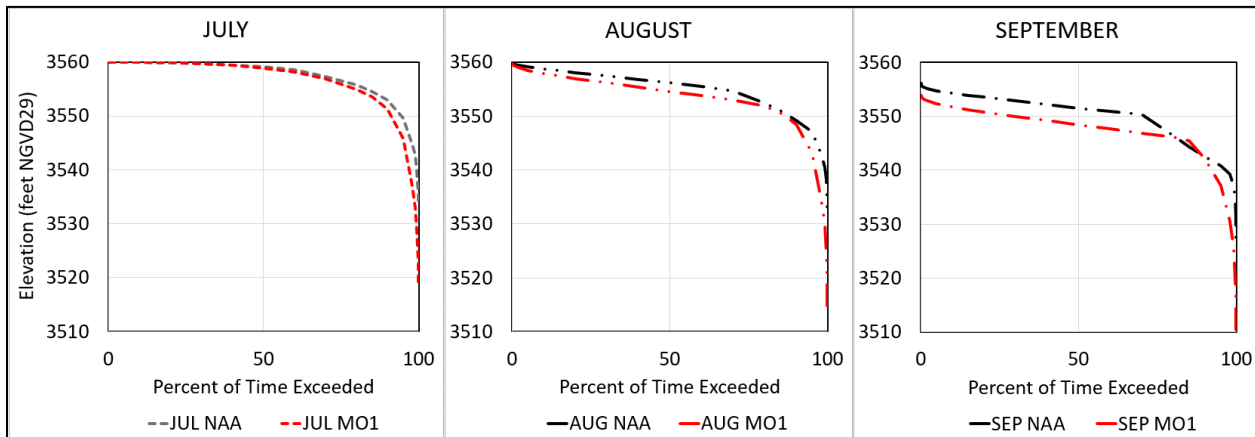
1034 Water levels at Hungry Horse Reservoir under MO1 would differ from the No Action Alternative
 1035 to varying extents, depending on the water year type. Median hydrographs of the reservoir
 1036 level for dry, average, and wet years are shown in Figure 3-26.



1037
 1038
 1039

Figure 3-26. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 1

1040 Finally, the three panels in Figure 3-27 show Hungry Horse Reservoir elevation duration curves
 1041 for the months of July, August, and September, respectively. While other months also have
 1042 differences, these three are shown because of interest in summer reservoir elevations. In
 1043 general, the reservoir level in the summer months would be lower for MO1 than for the No
 1044 Action Alternative. For instance, the daily reservoir elevation in September would be above
 1045 elevation 3,550 feet NGVD29 only about 30 percent of the time under MO1, whereas it would
 1046 be above that elevation about 70 percent of the time under the No Action Alternative.

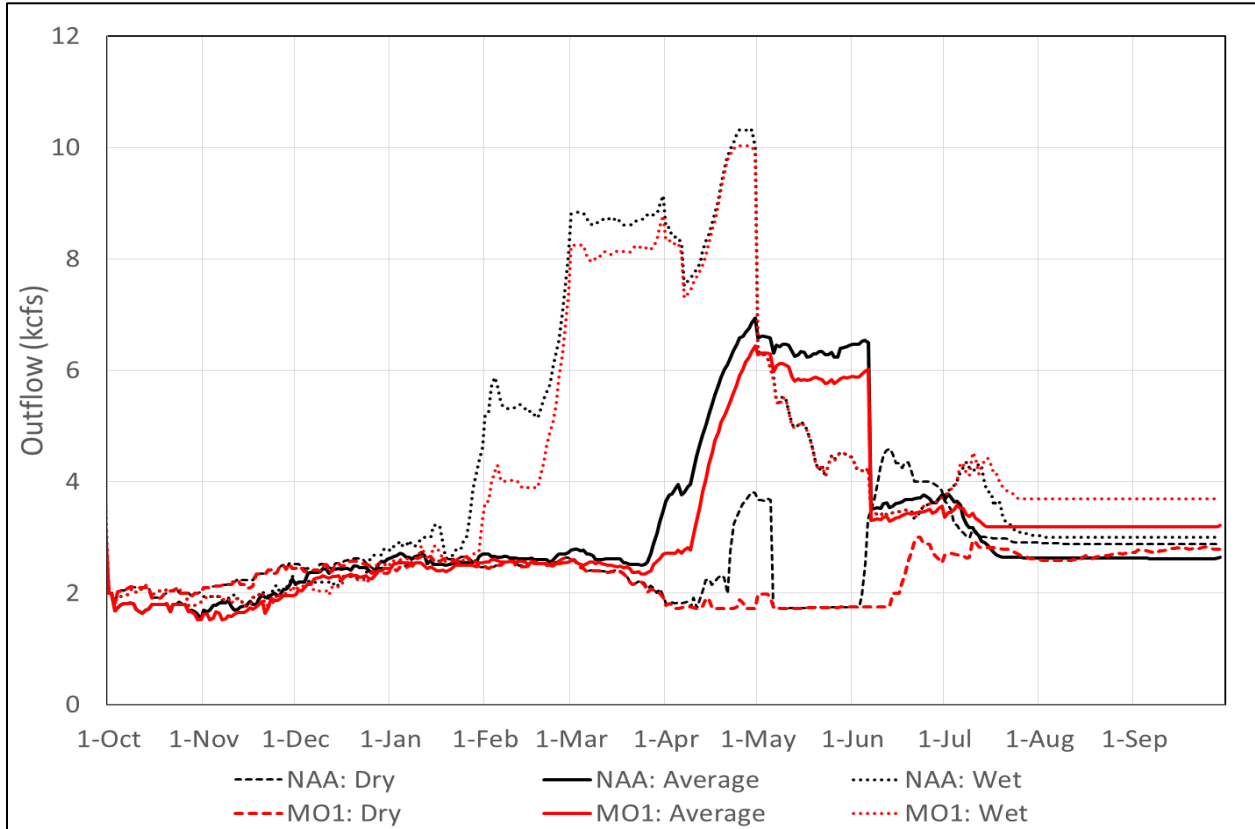


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 1048

Figure 3-27. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 1

1049 **Hungry Horse Dam Outflow**

1050 Under MO1, the Hungry Horse Additional Water Supply and *Sliding Scale at Libby and Hungry*
 1051 *Horse* measures would have a direct effect on Hungry Horse Dam outflows. The outflows would
 1052 differ from the No Action Alternative depending on the time of year. Figure 3-28 shows median
 1053 hydrographs for Hungry Horse Dam outflow in dry, average, and wet years.



1054 **Figure 3-28. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 1055 **Alternative 1**
 1056

1057 The change in average monthly outflow from Hungry Horse Dam throughout the water year is
 1058 presented in Table 3-11.

1059 Average outflow from Hungry Horse Dam would differ from the No Action Alternative:

- 1060 • In August and September, the median value of the monthly average outflow would increase
 1061 as compared to the No Action Alternative. The measures driving these changes are the
 1062 *Hungry Horse Additional Water Supply and Sliding Scale at Libby and Hungry Horse*
 1063 measures.
- 1064 • After September and through the spring, reservoir outflows would generally be lower than
 1065 for the No Action Alternative. The lower outflows would occur because the reservoir would
 1066 be drafted deeper at the end of September, and so would begin the water year at a lower
 1067 elevation than under the No Action Alternative.

1068 **Table 3-11. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 1**
1069 **(as change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	2.5	4.7	6.9	7.1	11.5	14.5	15.6	9.6	10.7	6.9	4.4	4.4
		25%	2.2	2.4	2.7	3.1	4.0	5.7	8.1	7.0	6.1	4.2	3.1	3.1
		50%	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7
		75%	1.4	1.4	2.1	2.3	2.4	2.2	3.1	4.1	3.2	2.6	2.4	2.4
		99%	0.8	0.8	1.6	2.0	1.7	1.5	1.7	1.7	1.7	1.7	1.8	1.9
MO1	Change (kcfs)	1%	0.0	-0.5	-2.2	-0.8	-0.1	-0.2	-0.2	-0.1	-0.3	0.0	-0.1	-0.1
		25%	0.0	0.0	-0.1	-0.4	-0.8	-0.7	-0.4	-0.3	-0.4	0.0	0.5	0.5
		50%	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.7	-0.4	-0.3	0.0	0.6	0.6
		75%	0.0	-0.2	-0.2	-0.2	-0.1	-0.1	-0.5	-0.4	-0.3	0.2	0.4	0.5
		99%	0.0	-0.2	-0.5	-0.3	-0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.3
	Percent change	1%	0%	-12%	-32%	-11%	-1%	-2%	-1%	-1%	-3%	0%	-2%	-2%
		25%	0%	-1%	-4%	-12%	-21%	-12%	-5%	-4%	-7%	1%	17%	17%
		50%	0%	-6%	-6%	-3%	-4%	-6%	-13%	-6%	-8%	1%	21%	21%
		75%	-1%	-14%	-10%	-7%	-5%	-3%	-17%	-9%	-11%	9%	18%	19%
		99%	-2%	-29%	-29%	-14%	-5%	-2%	-2%	-1%	-3%	-2%	12%	17%

1070 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO1 flows lower than the No
1071 Action Alternative flows; green shading denotes MO1 flows higher than the No Action Alternative flows.

1072 While the initial Hungry Horse Reservoir levels at the start of each water year were erroneously
1073 set lower than intended, the effects of this initialization on Hungry Horse discharge are smaller
1074 than the effects on reservoir elevation. The results in the table above are close to what would
1075 be expected for MO1. Winter flows would be lower than for the No Action Alternative, with
1076 flows at the 1 percent exceedance level being the most affected, with an artificial modeling
1077 reduction from the lower starting pool initialization error. (The artificial modeling reduction
1078 ranges from 0.2 to 0.9 kcfs at the 1 percent exceedance level.) By May and June, the artificial
1079 modeling reduction in flows from the initialization error is just 0.1 to 0.2 kcfs for most water
1080 year types. Moving downstream through the system, flow effects from initialization have less
1081 and less of an effect as the total river flows become larger and larger.

1082 **Columbia Falls Flow**

1083 Under MO1, the *Hungry Horse Additional Water Supply and Sliding Scale at Libby and Hungry*
1084 *Horse* measures would affect flows at Columbia Falls. Compared to the No Action Alternative,
1085 there would be increased flow in August and September in virtually all years, while the other
1086 months of the year would have flows similar to or less than those under the No Action
1087 Alternative, while still meeting minimum flow requirements. The change in average monthly
1088 flow at Columbia Falls throughout the water year, as compared to the No Action Alternative, is
1089 presented in Table 3-12.

1090 **Table 3-12. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 1 (as**
1091 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	8.9	14.4	14.8	11.0	14.2	17.4	30.5	38.0	43.2	23.9	8.8	8.7
		25%	4.0	4.2	4.5	5.0	5.8	7.9	15.9	29.7	31.5	15.1	6.9	5.4
		50%	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7
		75%	3.6	3.6	3.6	3.6	3.6	3.7	8.5	21.4	20.0	8.4	4.9	4.2
		99%	3.5	3.5	3.5	3.5	3.5	3.5	5.4	15.7	12.4	5.5	3.9	3.6
MO1	Change (kcfs)	1%	-1.5	-2.3	-3.4	-1.3	-0.2	-0.4	-0.4	-0.2	-0.2	-0.1	0.7	-0.1
		25%	0.0	0.0	-0.6	-0.8	-0.9	-0.6	-0.6	-0.3	-0.2	0.2	0.5	0.6
		50%	0.0	0.0	0.0	-0.1	-0.1	-0.4	-0.7	-0.3	-0.2	0.2	0.4	0.5
		75%	0.0	0.0	0.0	0.0	0.0	0.0	-0.5	-0.5	-0.5	0.0	0.3	0.3
		99%	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	-0.4	-0.4	-0.3	0.1	0.3
	Percent change	1%	-17%	-16%	-23%	-12%	-1%	-3%	-1%	-1%	0%	0%	8%	-1%
		25%	0%	-1%	-14%	-15%	-15%	-7%	-3%	-1%	-1%	1%	8%	11%
		50%	0%	-1%	0%	-2%	-2%	-9%	-6%	-1%	-1%	2%	7%	11%
		75%	1%	0%	0%	0%	0%	-1%	-6%	-2%	-3%	0%	6%	8%
		99%	0%	0%	0%	-1%	0%	0%	-7%	-2%	-3%	-5%	2%	10%

1092 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO1 flows lower than the No
1093 Action Alternative flows; green shading denotes MO1 flows higher than the No Action Alternative flows.

1094 **Lake Pend Oreille Elevation**

1095 While the *Hungry Horse Additional Water Supply* and *Sliding Scale at Libby and Hungry Horse*
1096 measures in MO1 would affect Hungry Horse Dam operations, the changes would not impact
1097 annual peak reservoir levels and would not change the timing of refill or drawdown. Thus, there
1098 would not be any noticeable difference in the level of Lake Pend Oreille as compared to the No
1099 Action Alternative.

1100 **Albeni Falls Outflow**

1101 Under MO1, the *Hungry Horse Additional Water Supply* and *Sliding Scale at Libby and Hungry*
1102 *Horse* measures would affect the monthly average outflow from Albeni Falls Dam, but to a
1103 lesser degree than at Hungry Horse Dam or Columbia Falls. In January through July, and again in
1104 September, the median value of the monthly average outflow from Albeni Falls Dam under
1105 MO1 would be 0.1 kcfs to 0.7 kcfs less than the No Action Alternative, depending on the month.
1106 This is shown in Table 3-13.

1107 **Table 3-13. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 1 (as**
1108 **change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcfs)	Hungry Horse	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7
	Columbia Falls, MT	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7
	Albeni Falls	23.7	16.7	15.3	14.5	16.6	19.8	25.2	50.7	55.6	27.4	12.0	13.7
Change (kcfs)	Hungry Horse	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.7	-0.4	-0.3	0.0	0.6	0.6
	Columbia Falls, MT	0.0	0.0	0.0	-0.1	-0.1	-0.4	-0.7	-0.3	-0.2	0.2	0.4	0.5
	Albeni Falls	0.0	0.0	0.0	-0.1	-0.4	-0.2	-0.7	-0.5	-0.3	-0.3	0.0	-0.1
Percent Change	Hungry Horse	0%	-6%	-6%	-3%	-4%	-6%	-13%	-6%	-8%	1%	21%	21%
	Columbia Falls, MT	0%	-1%	0%	-2%	-2%	-9%	-6%	-1%	-1%	2%	7%	11%
	Albeni Falls	0%	0%	0%	-1%	-2%	-1%	-3%	-1%	-1%	-1%	0%	-1%

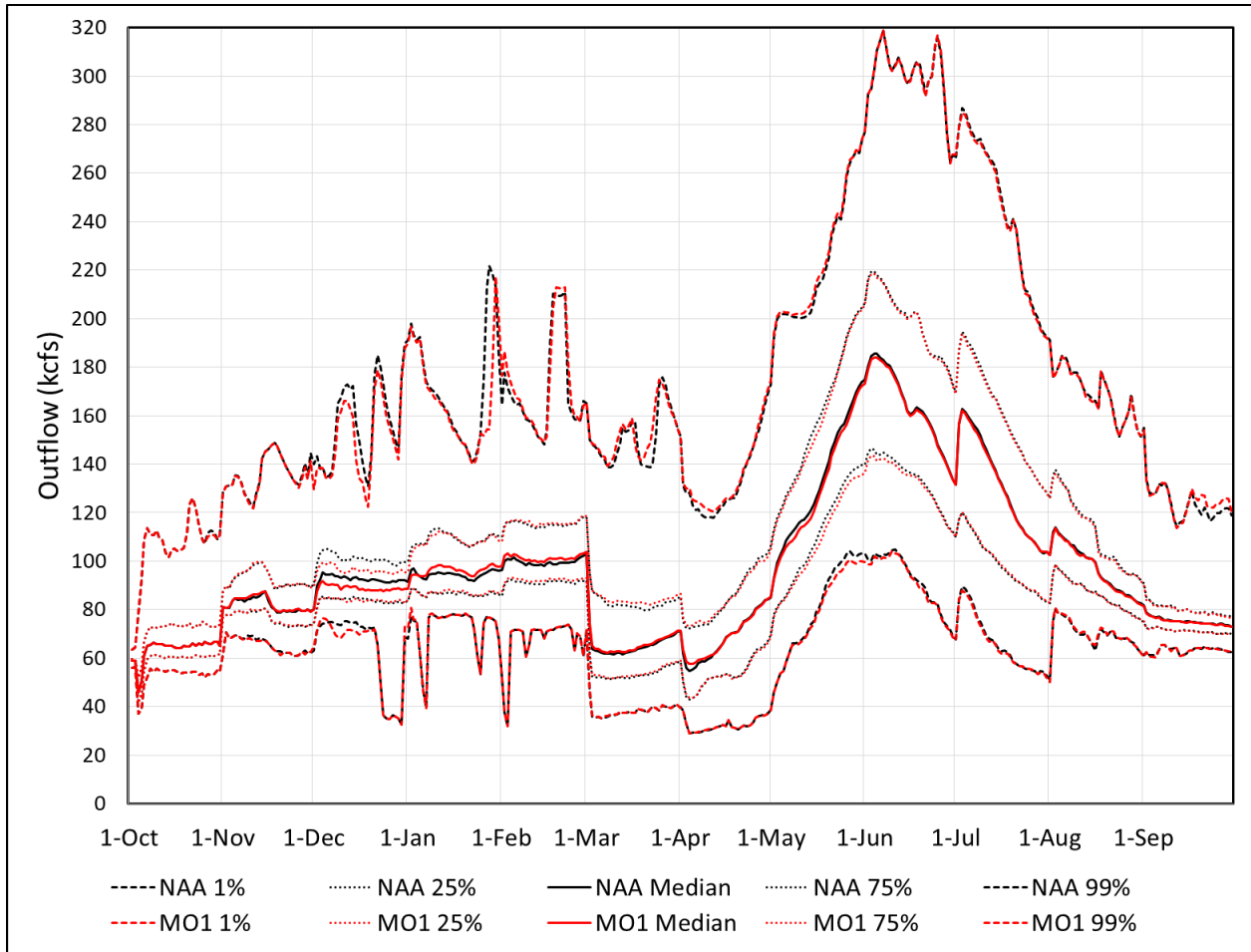
1109 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO1 flows lower than the No
1110 Action Alternative flows; green shading denotes MO1 flows higher than the No Action Alternative flows.

1111 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

1112 **Columbia River flow upstream of Grand Coulee Dam**

1113 Under MO1, the *Modified Draft at Libby, December Libby Target Elevation, Sliding Scale at Libby*
1114 *and Hungry Horse, and Hungry Horse Additional Water Supply* measures would affect Columbia
1115 River flow upstream of Grand Coulee Dam. The flows are depicted in Figure 3-29, which shows
1116 flows near RM 748 (just downstream of the U.S.-Canada border, about 151 river miles
1117 upstream of Grand Coulee Dam).

1118 Figure 3-29 characterizes the timing and magnitude of flow changes between the No Action
1119 Alternative and MO1 due to the combined effect of measures at Libby Dam and Hungry Horse
1120 Dam. Changes in flow between MO1 and the No Action Alternative would be most noticeable in
1121 December. In December, the median flow for MO1 would be about 4 kcfs lower than for the No
1122 Action Alternative due to the *December Libby Target Elevation* measure.



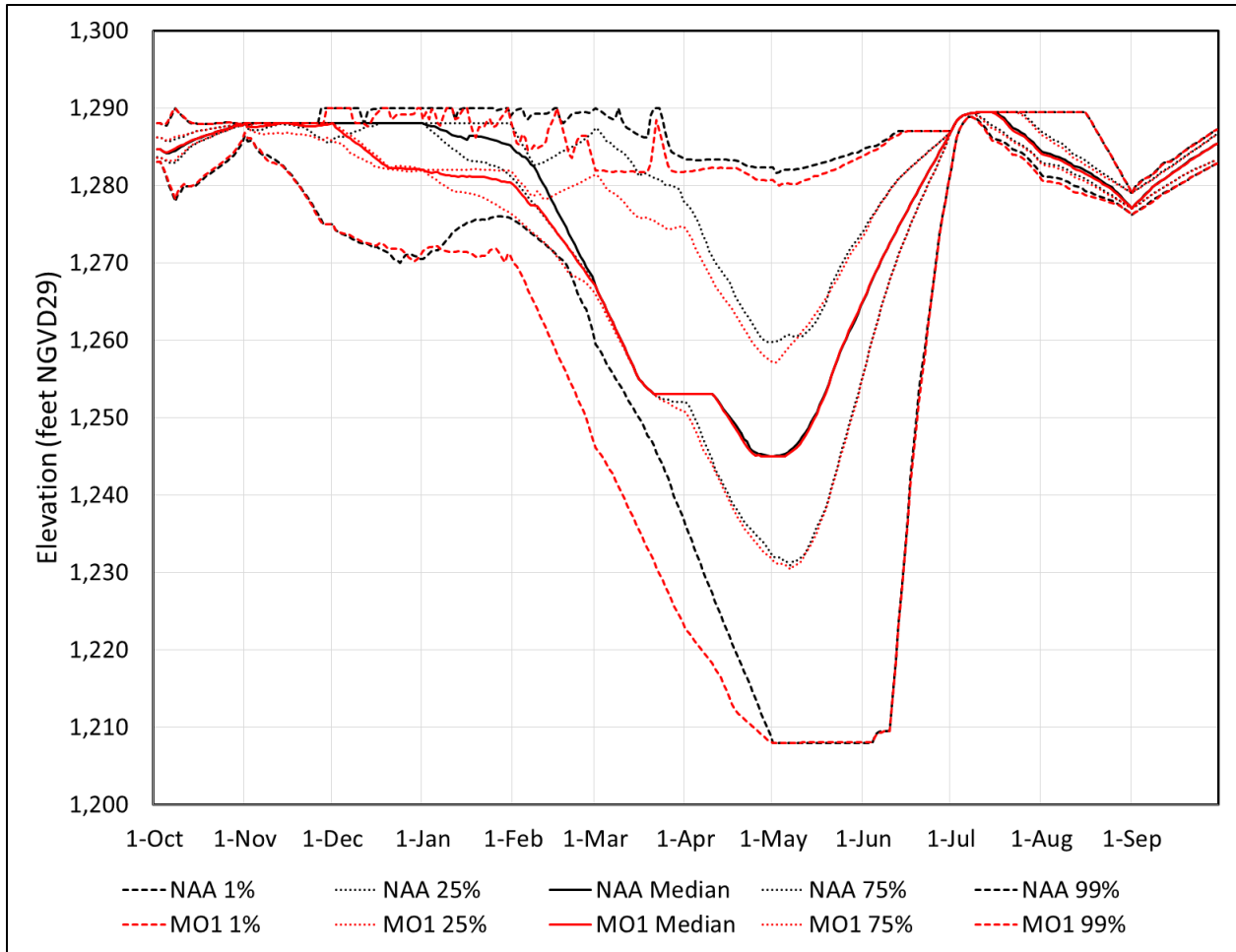
1123
 1124 **Figure 3-29. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 1**

1125 **Lake Roosevelt (Grand Coulee Dam Reservoir) Elevation**

1126 Under MO1, the *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee*, and
 1127 *Winter System FRM Space* measures relate directly to Grand Coulee Dam and would influence
 1128 reservoir elevations at Lake Roosevelt.

1129 In addition to the operational measures listed above, the *Modified Draft at Libby*, *December*
 1130 *Libby Target Elevation*, *Sliding Scale at Libby and Hungry Horse*, and *Hungry Horse Additional*
 1131 *Water Supply* measures would affect inflow to Grand Coulee Dam. The hydroregulation
 1132 modeling performed for MO1 incorporates all of these measures, but because each measure
 1133 was not evaluated in isolation from the others, drawing a direct linkage between a single
 1134 measure and an effect is not always possible. The effects that would occur from a measure or
 1135 combination of measures are identified and discussed to the extent possible.

1136 Reservoir water levels in Lake Roosevelt under MO1 would differ from the No Action
 1137 Alternative, as shown in Figure 3-30.



1138
 1139

Figure 3-30. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 1

1140 Under MO1, the reservoir elevation would be lower from December through February in
 1141 virtually all years, as compared to the No Action Alternative. This is primarily due to the *Winter*
 1142 *System FRM Space* measure, which would increase the space available at Grand Coulee Dam for
 1143 FRM in the winter months when rain-induced floods may occur. The *Winter System FRM Space*
 1144 measure calls for 650 kaf of space in the reservoir by the end of December. The *Planned Draft*
 1145 *Rate at Grand Coulee* measure decreases the daily draft rate in planning drawdown to the
 1146 deepest draft point, as determined by the *Update System FRM Calculation* measure. In the
 1147 wettest years the *Planned Draft Rate at Grand Coulee* measure requires earlier draft, but this
 1148 earlier draft is largely started already due to the *Winter System FRM Space* measure. From mid-
 1149 December through January, the median monthly reservoir elevation would be about 5 feet
 1150 lower under MO1 than it would be under the No Action Alternative. By January 31, the
 1151 reservoir level would consistently be about 4 to 6 feet lower under MO1 than it would be under
 1152 the No Action Alternative. By March 1, the median reservoir levels for MO1 realign with those
 1153 in the No Action Alternative, and match almost exactly from May through November. The *Lake*
 1154 *Roosevelt Additional Water Supply* measure would be implemented starting in the spring,
 1155 increasing pumping from Lake Roosevelt. This would affect reservoir outflows but not reservoir
 1156 elevations.

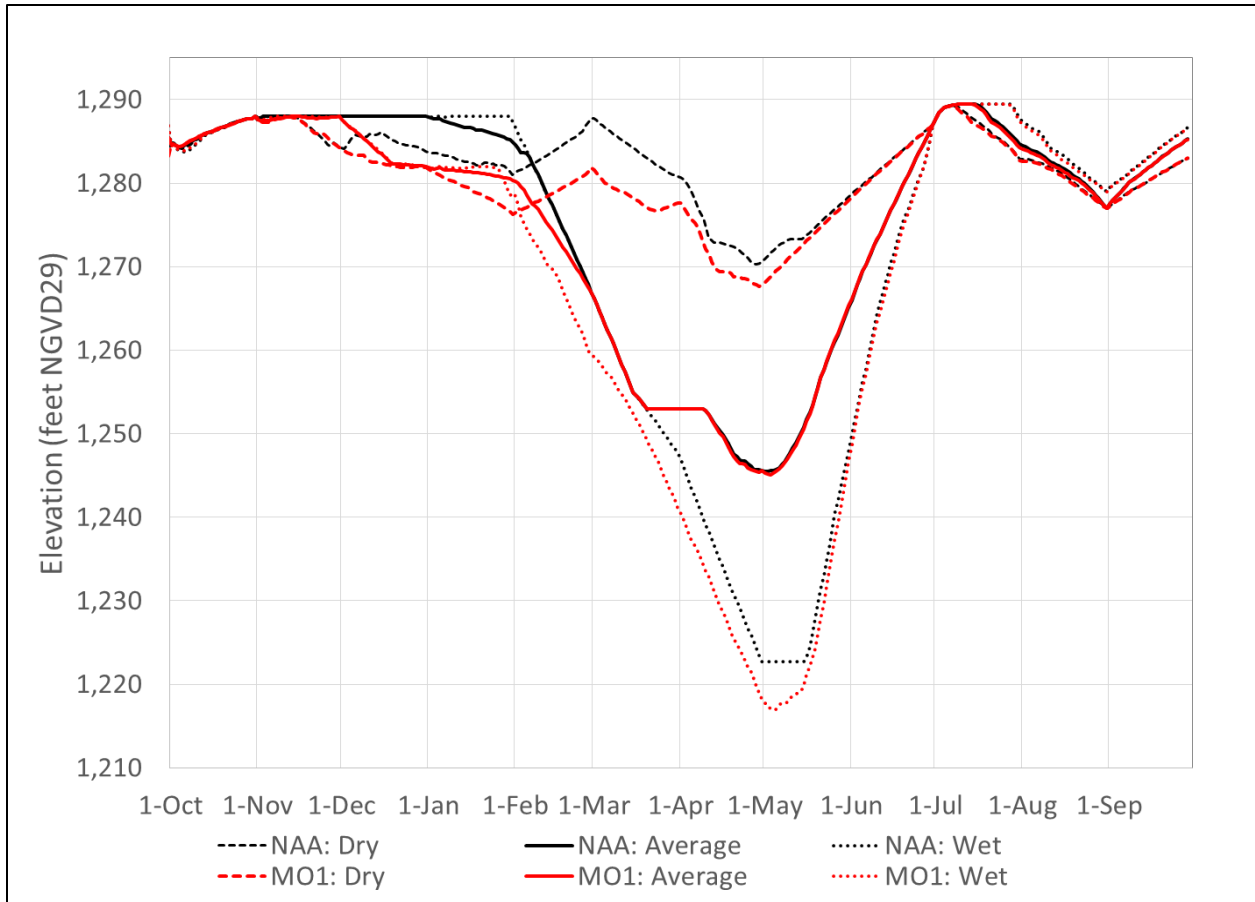
1157 In some years, the reservoir elevation under MO1 would be lower than the No Action
1158 Alternative until the start of May due to *Update System FRM Calculation*. This generally occurs
1159 in years with high runoff volumes (the highest 20 percent of years), when the earlier planned
1160 drawdown called for by the *Update System FRM Calculation* measure comes into play, and is
1161 the governing reason for the reservoir's drawdown trajectory.

1162 Under MO1, the probability of drafting to very low reservoir elevations (elevation 1,222 feet
1163 NGVD29 or below) at Lake Roosevelt on April 30 would increase when compared to the No
1164 Action Alternative. This is due to an element in the *Update System FRM Calculation* measure
1165 which calls for the FRM space requirement at Grand Coulee Dam to increase as the water
1166 supply forecast increases. This is in contrast to the FRM space requirement at Grand Coulee
1167 Dam for the No Action Alternative, which has a "flat spot" at elevation 1,222.7 feet NGVD29
1168 where the FRM space requirement does not increase right away with the runoff forecast over a
1169 certain range of runoff conditions.

1170 The effects of MO1 on the April 30 level of Lake Roosevelt are summarized below:

- 1171 • The chance of drawing the reservoir down to "empty" (elevation 1,208 feet NGVD29) on
1172 April 30 would be about 7 percent for MO1, as compared to about a 5 percent chance for
1173 the No Action Alternative.
- 1174 • The chance of drawing the reservoir down to elevation 1,222 feet NGVD29 or below on
1175 April 30 would be about 15 percent for MO1, as compared to about 8 percent for the No
1176 Action Alternative.

1177 Finally, Figure 3-31 shows median hydrographs for Lake Roosevelt in dry, average, and wet
1178 years. The figure provides another way to picture the effects described above, this time
1179 categorized by water year type.



1180
 1181 **Figure 3-31. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative**
 1182 **1**

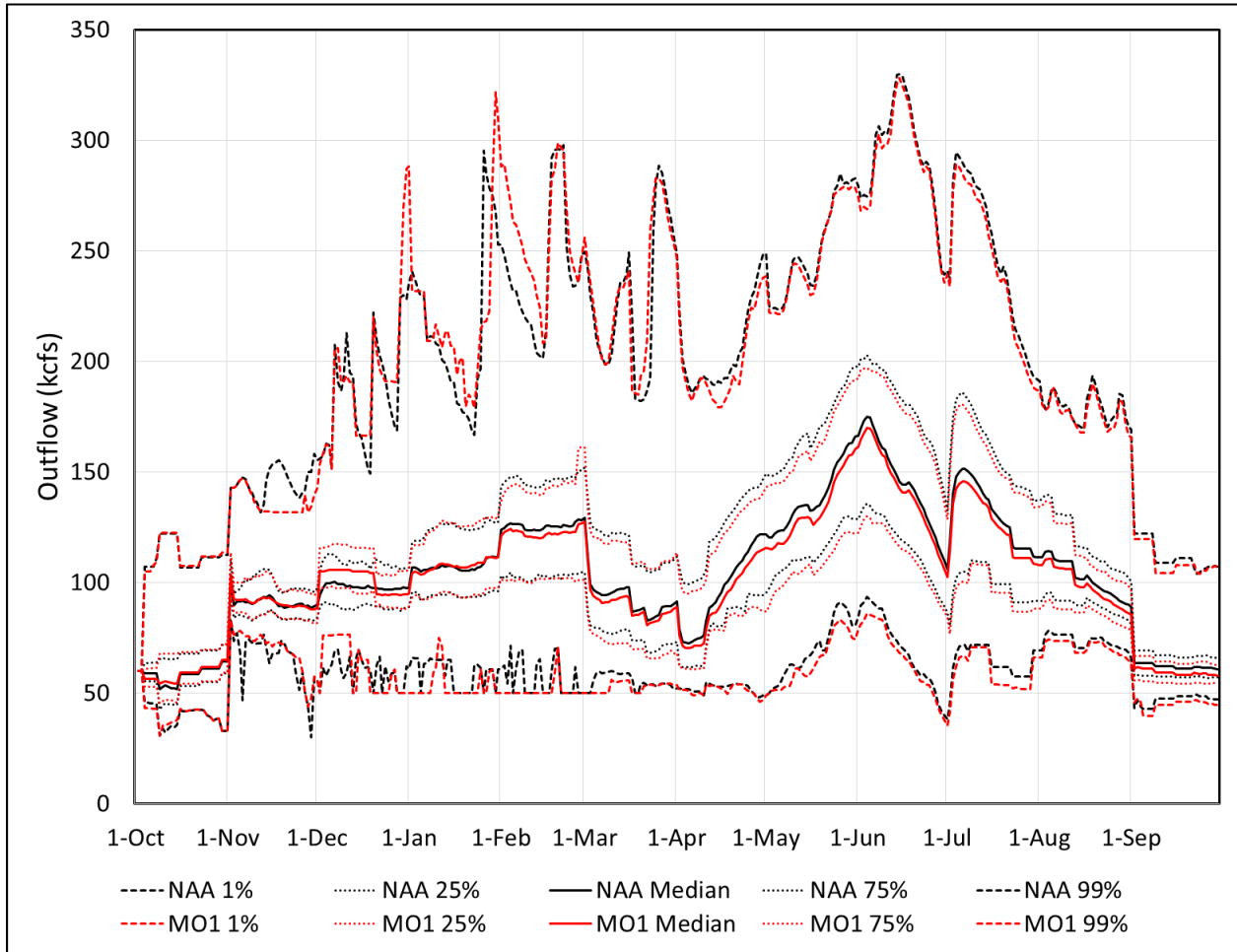
1183 **Grand Coulee Dam Drum Gate Maintenance**

1184 Drum gate maintenance at Grand Coulee Dam is planned to occur annually during March, April,
 1185 and May, but is not conducted in all years. The reservoir must be at or below elevation 1,255
 1186 feet NGVD29 for 8 weeks to complete drum gate maintenance. Under MO1, the *Update System*
 1187 *FRM Calculation, Planned Draft Rate at Grand Coulee, and Winter System FRM Space* measures
 1188 would influence reservoir elevations during spring months.

1189 The changes in elevations for MO1 that influence the decision to conduct drum gate
 1190 maintenance would not change significantly relative to the No Action Alternative (April 30 FRM
 1191 elevation targets and drum gate initiation methodology is discussed in more detail in Part 1 of
 1192 Appendix B). The decision to conduct drum gate maintenance is based on the February water
 1193 supply forecast and the resulting April 30 FRM elevation projection (April 30 FRM elevation
 1194 target at or below 1,255 or 1,265 feet NGVD29 depending on how recently the maintenance
 1195 has been conducted). That is not to say the spring elevations are the same for the two
 1196 alternatives, but rather there are a similar number of years that elevations would allow for
 1197 drum gate maintenance. In both MO1 and the No Action Alternative, drum gate maintenance
 1198 would be achievable in 65 percent of the years.

1199 **Grand Coulee Dam Outflow**

1200 Under MO1, the *Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Winter*
 1201 *System FRM Space, and Lake Roosevelt Additional Water Supply* measures would directly affect
 1202 outflows from Grand Coulee Dam. In addition, the *Modified Draft at Libby, December Libby*
 1203 *Target Elevation, Sliding Scale at Libby and Hungry Horse, and Hungry Horse Additional Water*
 1204 *Supply* measures would affect inflows and outflows at Grand Coulee Dam. The outflows from
 1205 Grand Coulee Dam would differ from the No Action Alternative depending on the time of year,
 1206 as seen in Figure 3-32.



1207 **Figure 3-32. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective**
 1208 **Alternative 1**
 1209

1210 The change in average monthly outflow throughout the water year is presented in Table 3-14.

1211 The *Lake Roosevelt Additional Water Supply* measure calls for an increased volume of water to
 1212 be pumped from Lake Roosevelt into Banks Lake, which would directly affect Grand Coulee
 1213 Dam outflows. Because several other measures in MO1 would also affect Grand Coulee Dam's
 1214 outflow, the effects of MO1 are described below, identifying the measure (or combination of
 1215 measures) responsible for the change where possible.

1216 **Table 3-14. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 1**
1217 **(as change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	94	130	174	190	213	186	191	231	275	247	175	111
		25%	67	99	109	124	147	117	120	165	181	158	118	68
		50%	59	91	97	108	126	93	97	138	150	134	102	63
		75%	54	84	88	96	105	78	79	118	121	98	92	59
		99%	49	78	79	76	81	66	60	97	91	81	81	53
MO1	Change (kcfs)	1%	0.8	-0.3	1.5	4.7	14.7	-2.7	-7.7	-4.4	-1.3	-5.4	-3.4	-2.9
		25%	0.3	-0.7	2.2	0.1	-3.3	-0.1	-4.5	-6.2	-3.8	-4.3	-4.6	-2.9
		50%	0.4	0.0	3.8	0.6	-2.5	-2.3	-4.6	-6.1	-4.5	-4.7	-3.4	-2.9
		75%	0.3	0.0	5.7	0.5	-2.1	-4.1	-3.0	-5.8	-4.2	-4.1	-3.3	-2.6
		99%	0.4	0.0	3.6	6.3	2.5	-3.1	-1.3	-8.9	-4.9	-3.6	-3.2	-2.7
	Percent change	1%	1%	0%	1%	2%	7%	-1%	-4%	-2%	0%	-2%	-2%	-3%
		25%	1%	-1%	2%	0%	-2%	0%	-4%	-4%	-2%	-3%	-4%	-4%
		50%	1%	0%	4%	1%	-2%	-3%	-5%	-4%	-3%	-3%	-3%	-5%
		75%	1%	0%	6%	1%	-2%	-5%	-4%	-5%	-3%	-4%	-4%	-4%
		99%	1%	0%	5%	8%	3%	-5%	-2%	-9%	-5%	-4%	-4%	-5%

1218 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO1 flows lower than the No
1219 Action Alternative flows; green shading denotes MO1 flows higher than the No Action Alternative flows.

1220 From the fall through spring, the outflow from Grand Coulee Dam under MO1 would differ from
1221 the No Action Alternative due to several FRM-related measures at Grand Coulee Dam.

1222 • In December, the median value of the monthly average outflow would increase by 3.8 kcfs,
1223 primarily due to the *Winter System FRM Space* measure which creates winter FRM space in
1224 Grand Coulee’s reservoir.

1225 • In January, the median value of the monthly average outflow would increase by 0.6 kcfs.
1226 This may be caused by the *Winter System FRM Space* measure, which continues to draft
1227 Grand Coulee’s reservoir in January if the winter FRM space is not achieved by the end of
1228 December. The *Update System FRM Calculation* and *Planned Draft Rate at Grand Coulee*
1229 measures can also influence flows in January.

1230 • The *Planned Draft Rate at Grand Coulee* measure would reduce the designed draft rate for
1231 the Grand Coulee Dam Storage Reservation Diagram (SRD), which aims to initiate the
1232 system FRM draft earlier in the winter. However, the *Winter System FRM Space* measure
1233 would have a larger effect on the winter releases as even with the earlier draft targets,
1234 Grand Coulee Dam’s median average outflow in February and March would be reduced by
1235 2.5 and 2.3 kcfs, respectively.

1236 • In February and March, the median value of the monthly average outflow would decrease
1237 by 2.5 and 2.3 kcfs, respectively.

1238 • In April the volume of water to be pumped from Lake Roosevelt into Banks Lake would
1239 increase due to the *Lake Roosevelt Additional Water Supply* measure. The April through

1240 September period would have the greatest total pumping volumes, as well as the greatest
1241 additional pumping volumes as called for in the *Lake Roosevelt Additional Water Supply*
1242 measure.

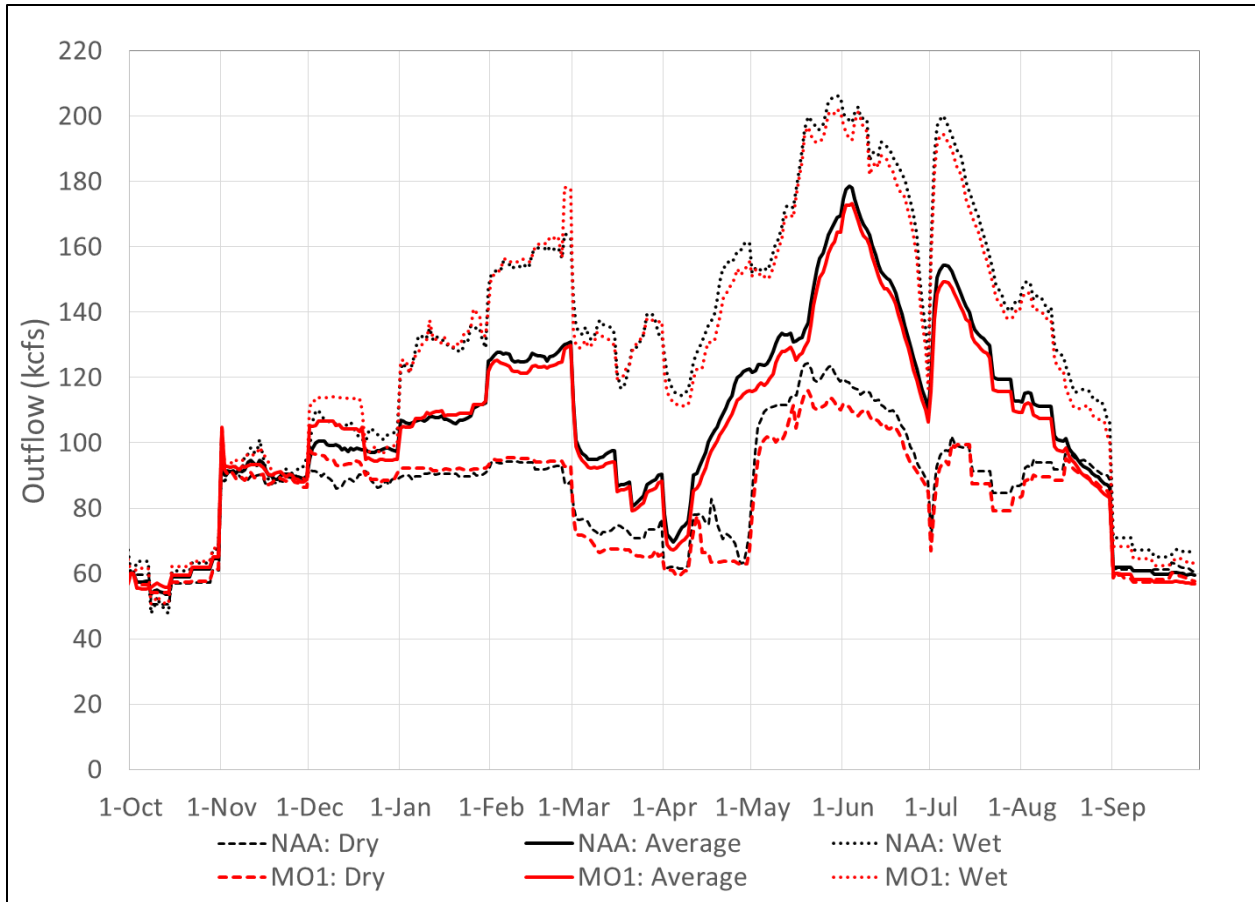
1243 • In April, the median value of the monthly average outflow would decrease by 4.6 kcfs; the
1244 *Lake Roosevelt Additional Water Supply* measure's increased pumping from Lake Roosevelt
1245 into Banks Lake accounts for the majority (3.2 kcfs) of this decrease. The *Update System*
1246 *FRM Calculation* and *Planned Draft Rate at Grand Coulee* measures, as well as changes to
1247 inflow from measures changing operations at upstream storage projects, would also affect
1248 Grand Coulee Dam outflows in April.

1249 • The median value of the monthly average outflow would decrease by 6.1 and 4.5 kcfs for
1250 May and June, respectively. The *Lake Roosevelt Additional Water Supply* measure's
1251 increased pumping from Lake Roosevelt into Banks Lake accounts for the majority of this
1252 outflow reduction, but not all of it. The *Lake Roosevelt Additional Water Supply* measure
1253 would decrease outflows by 3.2 and 3.0 kcfs in May and June, respectively. The *Update*
1254 *System FRM Calculation* measure and changes to inflow from operational measures
1255 changing operations at upstream storage projects, would also affect flows in May and June.

1256 • In July, August, and September, the median value of the monthly average outflow would be
1257 reduced by 4.6, 3.4, and 3.0 kcfs, respectively. This is almost exclusively due to the *Lake*
1258 *Roosevelt Additional Water Supply* measure. The *Lake Roosevelt Additional Water Supply*
1259 measure would decrease flows by 4.2, 2.6, and 2.5 kcfs in July, August, and September
1260 respectively.

1261 • The *Grand Coulee Maintenance Operations* measure would not impact reservoir elevations
1262 or total outflows, but would reduce the hydraulic capacity through the power plants,
1263 resulting in additional spill and an increase in TDG in some situations.

1264 Finally, Figure 3-33 shows median hydrographs for Grand Coulee Dam outflow in dry, average,
1265 and wet years. The figure provides another way to picture the effects described above, this
1266 time categorized by water year type.



1267
 1268 **Figure 3-33. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 1269 **Alternative 1**

1270 **Middle Columbia River below Grand Coulee Dam**

1271 Under MO1, the pattern of flow changes in the middle Columbia River would be similar to those
 1272 described for Grand Coulee Dam outflow, with the changes occurring for the same reasons as
 1273 described for Grand Coulee Dam outflow. An additional measure, *Chief Joseph Dam Project*
 1274 *Additional Water Supply*, calls for an increase in water diversion (at a maximum rate of 0.05
 1275 kcfs) from the Columbia River for the Chief Joseph Dam. The total flow impact from the *Chief*
 1276 *Joseph Dam Project Additional Water Supply* measure is 9.6 kaf annually, which is significantly
 1277 smaller than the impacts from the *Lake Roosevelt Additional Water Supply* measure that
 1278 reduces flows an additional 1.1 Maf annually. The maximum diversion rate associated with the
 1279 *Chief Joseph Dam Project Additional Water Supply* measure is two orders of magnitude less
 1280 than that for the *Lake Roosevelt Additional Water Supply* measure. The reservoir elevation at
 1281 Chief Joseph Dam would not change from the No Action Alternative.

1282 Table 3-15 shows changes in the median values of monthly average flows at locations in the
 1283 middle Columbia River.

1284 **Table 3-15. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative**
1285 **1 (as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcf/s)	Lake Roosevelt Inflow	64	82	92	95	100	65	69	131	166	133	98	75
	Grand Coulee	59	91	97	108	126	93	97	138	150	134	102	63
	Chief Joseph	58	91	96	108	127	94	98	139	150	135	103	63
	Wells	59	93	98	110	129	95	101	150	163	141	105	65
	Priest Rapids	60	96	102	115	133	100	108	162	178	147	108	68
Change (kcf/s)	Lake Roosevelt Inflow	0.0	0.7	-2.9	1.9	1.8	0.5	-0.6	-2.7	-0.4	-0.8	-0.3	-0.1
	Grand Coulee	0.4	0.0	3.8	0.6	-2.5	-2.3	-4.6	-6.1	-4.5	-4.7	-3.4	-2.9
	Chief Joseph	0.3	-0.1	3.8	0.9	-2.4	-2.6	-4.2	-6.3	-4.4	-4.9	-3.2	-2.8
	Wells	0.3	-0.1	3.7	0.8	-2.2	-2.4	-4.2	-6.5	-4.2	-5.1	-3.1	-2.8
	Priest Rapids	0.3	-0.1	3.9	0.9	-2.5	-2.2	-4.2	-6.6	-3.8	-4.4	-3.2	-2.8
Percent Change	Lake Roosevelt Inflow	0%	1%	-3%	2%	2%	1%	-1%	-2%	0%	-1%	0%	0%
	Grand Coulee	1%	0%	4%	1%	-2%	-3%	-5%	-4%	-3%	-3%	-3%	-5%
	Chief Joseph	1%	0%	4%	1%	-2%	-3%	-4%	-5%	-3%	-4%	-3%	-4%
	Wells	1%	0%	4%	1%	-2%	-3%	-4%	-4%	-3%	-4%	-3%	-4%
	Priest Rapids	1%	0%	4%	1%	-2%	-2%	-4%	-4%	-2%	-3%	-3%	-4%

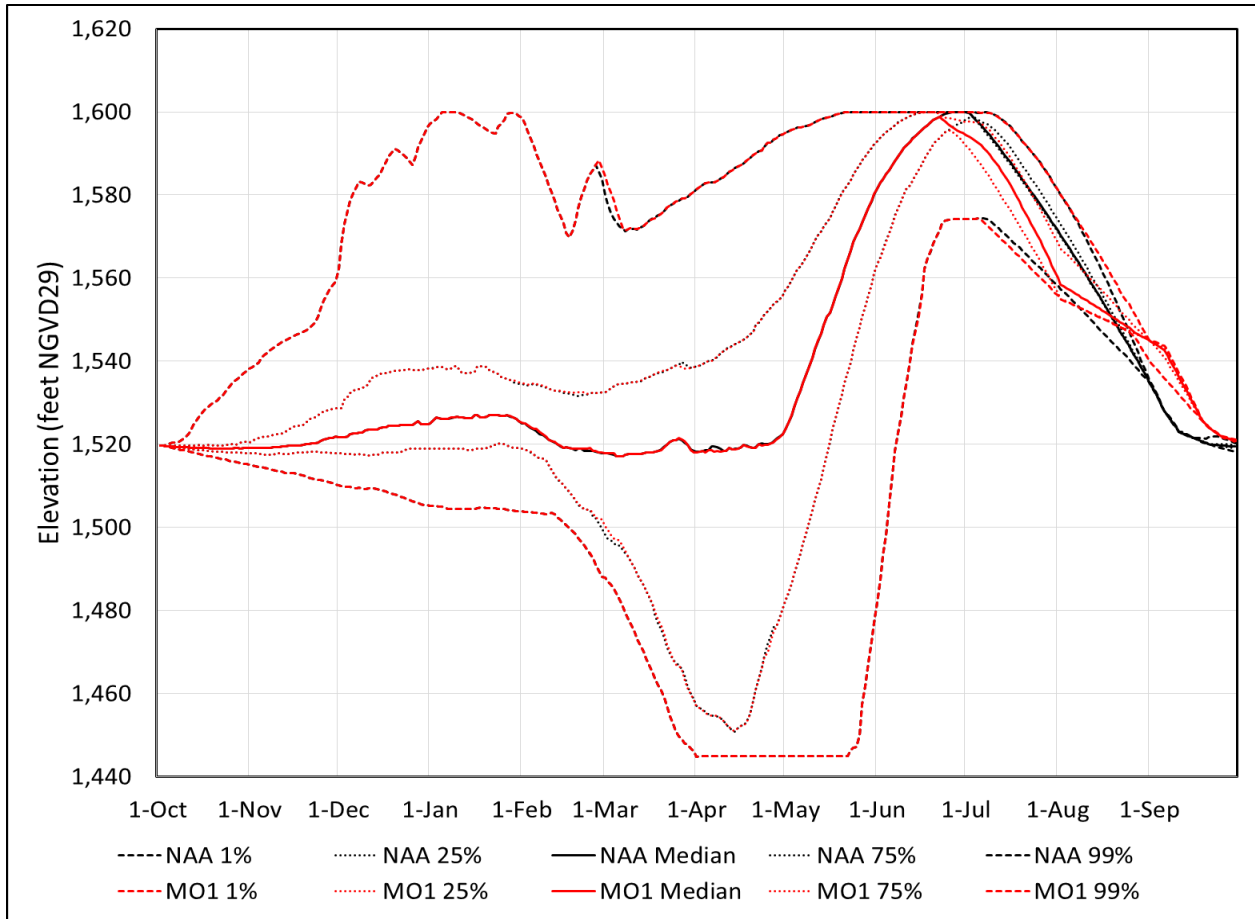
1286 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO1 flows lower than the No
1287 Action Alternative flows; green shading denotes MO1 flows higher than the No Action Alternative flows.

1288 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
1289 **HARBOR DAMS**

1290 **Dworshak Reservoir Elevation**

1291 Under MO1, the *Modified Dworshak Summer Draft* measure would have a direct effect on
1292 Dworshak Dam operations. Reservoir water levels would differ from the No Action Alternative,
1293 as shown in Figure 3-34.

1294 In MO1, the *Modified Dworshak Summer Draft* measure would modify the timing of water
1295 releases from Dworshak Dam in the summer to provide cooler water in the lower Snake River
1296 during peak adult fish migration periods. The reservoir would start drafting the day after refill,
1297 which means it would start drafting sometime after June 20 and no later than July 5. In
1298 contrast, under the No Action Alternative, the reservoir draft begins as early as July 1 and no
1299 later than July 7. The end of August target elevation would be 1,540 feet NGVD29 for years
1300 when the Dworshak water supply forecast is at or above the 80th percentile, and 1,545 feet
1301 NGVD29 when the forecast is below the 80th percentile. These are both higher than the end of
1302 August target for the No Action Alternative with the goal of reducing the discharge in August to
1303 save some cooling water for September. The end of September target elevation would be 1,520
1304 feet NGVD29, the same as for the No Action Alternative.



1305
1306 **Figure 3-34. Dworshak Reservoir Summary Hydrograph for Multiple Objective Alternative 1**

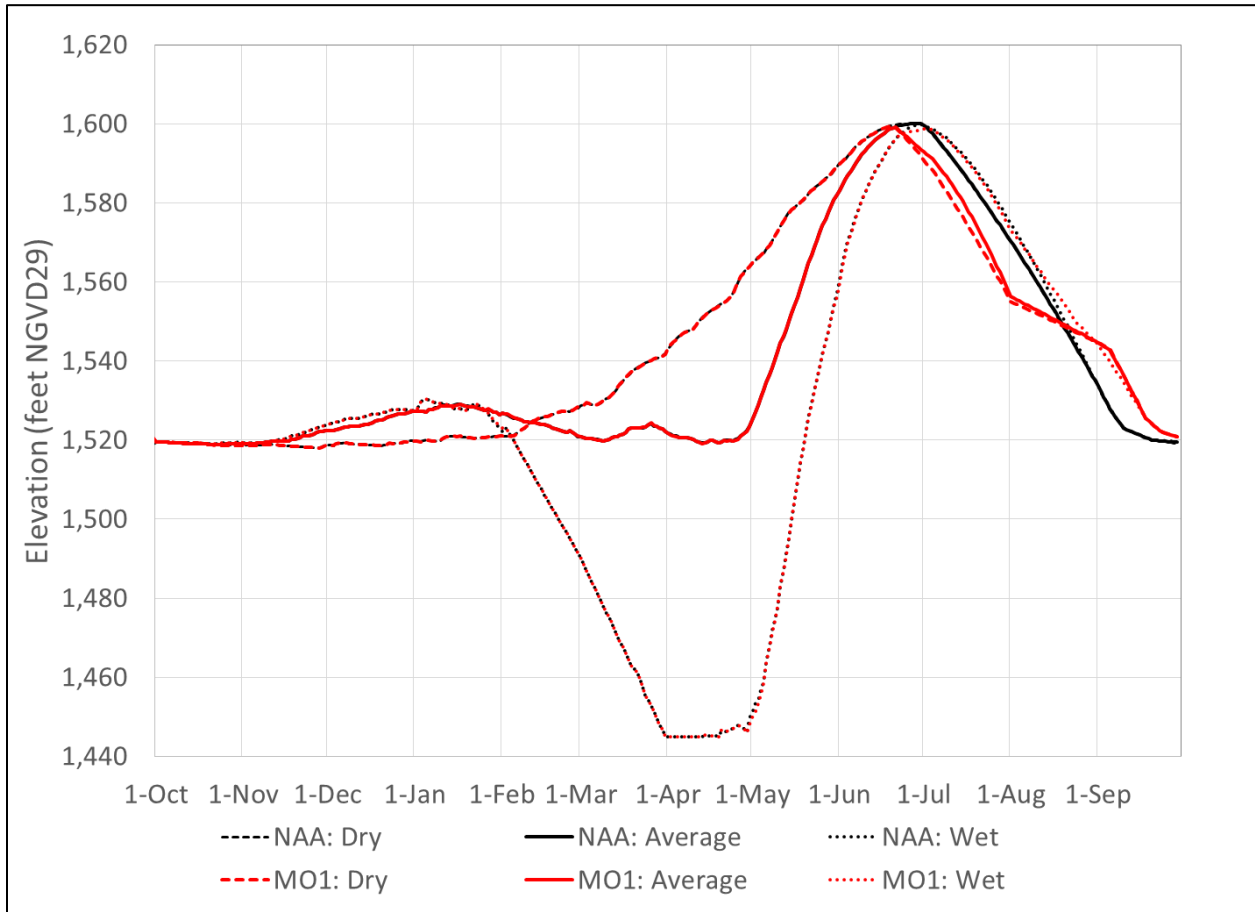
1307 Dworshak Dam’s reservoir elevation under MO1 would differ from the No Action Alternative
1308 due to the *Modified Dworshak Summer Draft* measure:

- 1309
- 1310 • From June 20 through mid to late August, reservoir water levels would be lower than those
 - 1311 for the No Action Alternative. (The difference varies by day but is generally about 5 to 10
 - 1312 feet lower.)
 - 1313 • From mid to late August through September, reservoir water levels would be higher than
 - 1314 those for the No Action Alternative. (The difference varies by day, but is generally about 5
 - to 10 feet higher.)

1315 At the end of September, the reservoir water level for MO1 would be the same as for the No
1316 Action Alternative.

1317 Under the No Action Alternative, Dworshak Reservoir refills to the normal full pool elevation of
1318 1,600 feet NGVD29 in about 80 percent of years. Under MO1, the probability of refilling would
1319 decrease by 1 to 3 percent on account of forcing the draft to initiate several days earlier than
1320 the No Action Alternative. Under MO1, typical reservoir levels on June 30 would be 3 to 8 feet
1321 lower than for the No Action Alternative.

1322 Water levels at Dworshak reservoir under MO1 would differ from the No Action Alternative to
 1323 varying extents, depending on the water year type. Median hydrographs of the reservoir level
 1324 for dry, average, and wet years are shown in Figure 3-35.

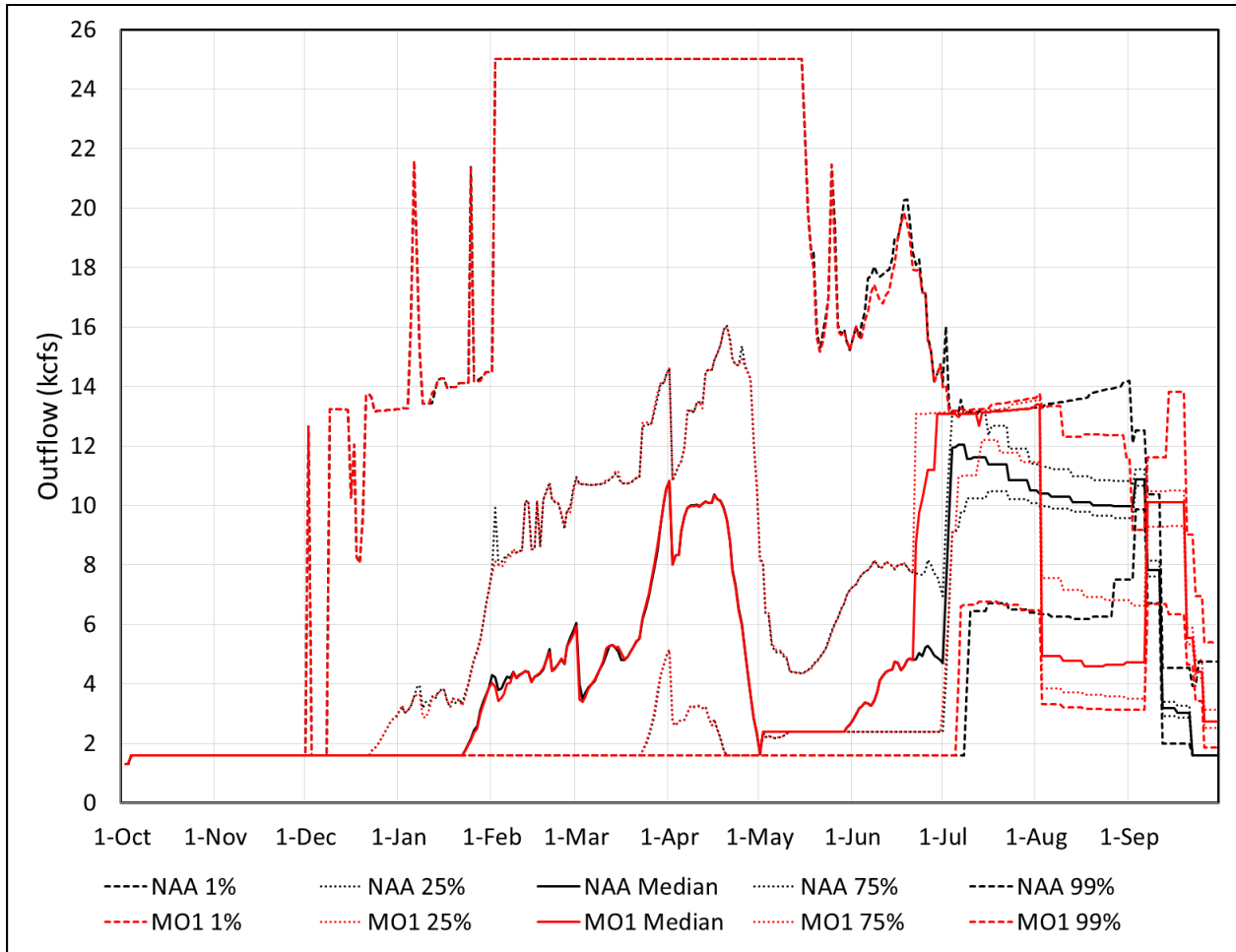


1325
 1326 **Figure 3-35. Dworshak Reservoir Water Year Type Hydrographs for Multiple Objective**
 1327 **Alternative 1**

1328 **Dworshak Dam Outflow**

1329 Under MO1, the *Modified Dworshak Summer Draft* measure would have a direct effect on
 1330 Dworshak Dam outflows. The outflows would differ from the No Action Alternative from June
 1331 through September, as seen in Figure 3-36.

1332 The change in average monthly outflow is characterized in Table 3-16. The months of June, July,
 1333 and September would all have an increase in outflow as compared to the No Action
 1334 Alternative. The month of August would have a decrease in outflow as compared to the No Action
 1335 Alternative.



1336
 1337
 1338

Figure 3-36. Dworshak Dam Outflow Summary Hydrograph for Multiple Objective Alternative 1

1339 From a comparison of MO1 with the No Action Alternative several conclusions can be made:

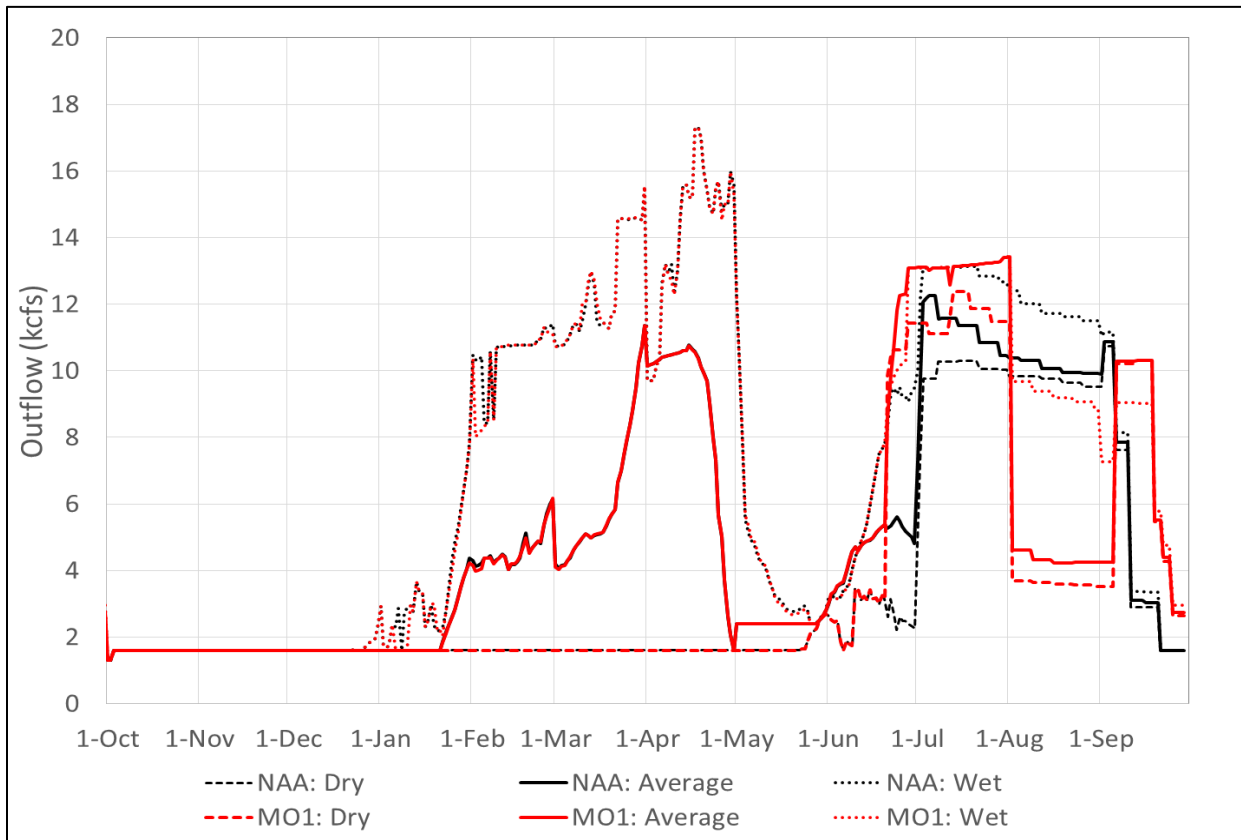
- 1340 • In June and July, the median value of the monthly average outflow would increase by 1.6
 1341 kcfs due to the *Modified Dworshak Summer Draft* measure.
- 1342 • In August, the median value of the monthly average outflow would decrease by 4.9 kcfs due
 1343 to the *Modified Dworshak Summer Draft* measure.
- 1344 • In September, the median value of the monthly average outflow would increase by 1.8 kcfs
 1345 due to the *Modified Dworshak Summer Draft* measure.

1346 Finally, Figure 3-37 shows median hydrographs for Dworshak Dam outflow in dry, average, and
 1347 wet years. The figure provides another way to picture the effects described above, this time
 1348 categorized by water year type.

1349 **Table 3-16. Dworshak Dam Monthly Average Outflow for Multiple Objective Alternative 1 (as**
1350 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	1.7	1.6	8.7	13.5	23.3	25.0	25.0	17.3	15.6	13.2	13.6	6.4
		25%	1.6	1.6	1.9	4.2	9.3	11.8	13.2	6.2	7.5	11.9	11.0	5.2
		50%	1.6	1.6	1.6	2.1	5.1	6.2	9.6	3.5	4.8	10.7	10.2	5.0
		75%	1.6	1.6	1.6	1.6	1.6	2.3	4.6	2.4	2.4	9.6	9.8	4.8
		99%	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	7.4	9.3
MO1	Change (kcfs)	1%	0.0	0.0	0.0	0.0	-1.9	0.0	0.0	0.0	0.1	0.1	-1.1	1.9
		25%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.3	-3.5	1.9
		50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6	-4.9	1.8
		75%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	-5.6	1.8
		99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	-5.5	1.5
	Percent change	1%	2%	0%	0%	0%	-8%	0%	0%	0%	0%	1%	-8%	29%
		25%	3%	0%	0%	0%	-1%	0%	0%	0%	23%	11%	-32%	37%
		50%	2%	0%	0%	0%	0%	1%	0%	0%	33%	15%	-48%	37%
		75%	2%	0%	0%	0%	0%	0%	0%	0%	0%	13%	-57%	37%
		99%	1%	0%	0%	0%	0%	0%	0%	0%	0%	38%	-59%	33%

1351 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO1 flows lower than the No
1352 Action Alternative flows; green shading denotes MO1 flows higher than the No Action Alternative flows.



1353 **Figure 3-37. Dworshak Dam Outflow Water Year Type Hydrographs for Multiple Objective**
1354 **Alternative 1**
1355

1356 **Lower Snake River Reservoir Elevations**

1357 Under MO1, the reservoir elevations at the four lower Snake River dams would differ from
1358 those of the No Action Alternative during the MOP season from April 3 through August 31 due
1359 to the *Increased Forebay Range Flexibility* measure. At each project the measure would
1360 increase the MOP range from 1.0 foot under the No Action Alternative to 1.5 feet under MO1.
1361 This is a 0.5-foot MOP range increase and a 0.5-foot increase in the upper elevation. There
1362 would be no changes the rest of the year. The MOP elevation ranges at each of the four lower
1363 Snake River dams are described below:

- 1364 • Lower Granite Dam: 733.0 to 734.5 feet NGVD29, compared to 733.0 to 734.0 feet NGVD29
1365 for No Action Alternative
- 1366 • Little Goose Dam: 633.0 to 634.5 feet NGVD29, compared to 633.0 to 634.0 feet NGVD29
1367 for No Action Alternative
- 1368 • Lower Monumental Dam: 537.0 to 538.5 feet NGVD29, compared to 537.0 to 538.0 feet
1369 NGVD29 for No Action Alternative
- 1370 • Ice Harbor Dam: 437.0 to 438.5 feet NGVD29, compared to 437.0 to 438.0 feet NGVD29 for
1371 No Action Alternative.

1372 **Clearwater River below Dworshak Dam and the Lower Snake River**

1373 Under MO1, the pattern of outflow changes from Dworshak Dam in June through September
1374 would continue downstream. While the percent changes in flow from the No Action Alternative
1375 would be pronounced in the Clearwater River system, they would become diluted at the
1376 confluence of the Clearwater River and the Snake River near Lewiston, Idaho. This is seen in
1377 Table 3-17, which shows changes in median values of monthly average flows. All changes are
1378 attributable to the *Modified Dworshak Summer Draft* measure in MO1.

1379 **Table 3-17. Lower Snake Basin Monthly Average Flows for Multiple Objective Alternative 1**
1380 **(as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcfs)	Dworshak	1.6	1.6	1.6	2.1	5.1	6.2	9.6	3.5	4.8	10.7	10.2	5.0
	Spalding, ID	3.4	4.5	4.7	5.9	10.6	15.5	26.8	33.4	28.7	17.0	12.2	6.5
	Snake+Clearwater	19.7	20.9	23.9	28.3	39.0	47.2	69.7	94.4	96.4	47.9	29.2	22.6
	Lower Granite	19.8	21.0	23.7	28.4	39.3	48.0	71.8	95.6	97.4	48.6	29.1	22.5
	Ice Harbor	20.2	21.4	24.5	29.4	42.0	50.7	73.0	95.4	97.2	48.4	28.1	21.2
Change (kcfs)	Dworshak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6	-4.9	1.8
	Spalding, ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.7	-5.0	1.8
	Snake+Clearwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.5	-4.9	1.8
	Lower Granite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.0	-4.5	1.8
	Ice Harbor	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.1	-4.5	1.9
Percent Change	Dworshak	2%	0%	0%	0%	0%	1%	0%	0%	33%	15%	-48%	37%
	Spalding, ID	1%	0%	0%	0%	0%	0%	0%	0%	6%	10%	-41%	28%
	Snake+Clearwater	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%	-17%	8%
	Lower Granite	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	-16%	8%
	Ice Harbor	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	-16%	9%

1381 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO1 flows greater than the
1382 No Action Alternative flows; green shading denotes MO1 flows less than the No Action Alternative flows.

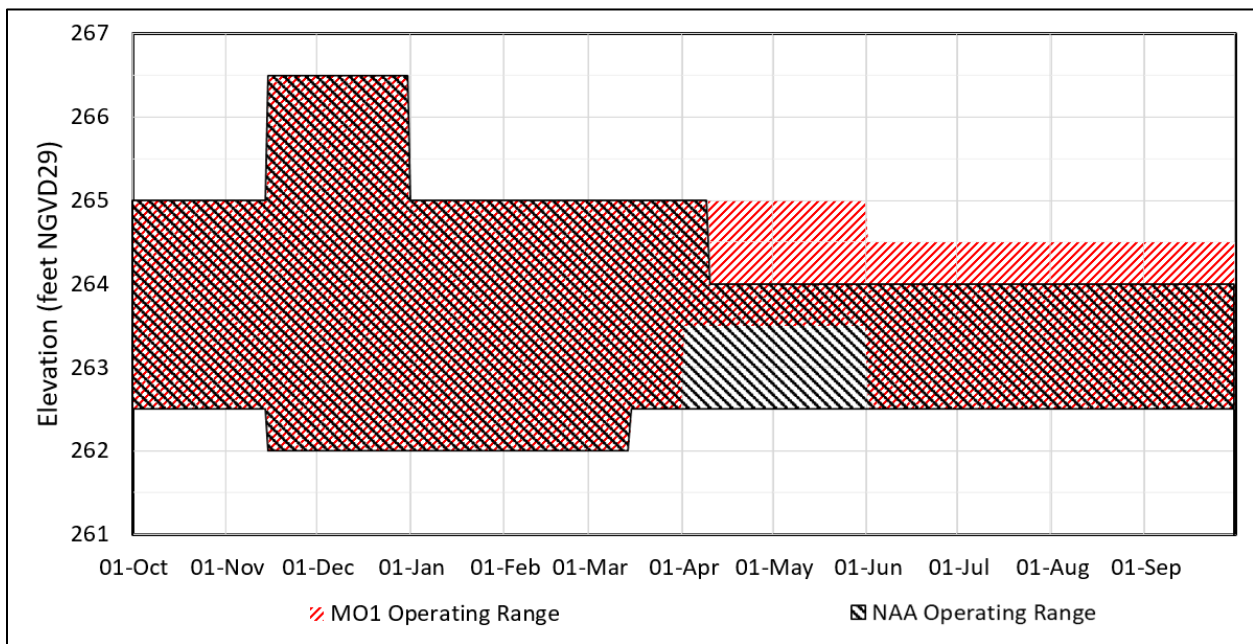
1383 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

1384 **Lower Columbia River Reservoir Elevations**

1385 Under MO1, there would be no changes to the reservoir elevations at McNary Dam, The Dalles
 1386 Dam, or Bonneville Dam. At John Day Dam, the *Predator Disruption Operations* and *Increased*
 1387 *Forebay Range Flexibility* measures relate to the reservoir operating range. The range in April
 1388 and May is due to the *Predator Disruption Operations* measure; the range in June through
 1389 September is due to the *Increased Forebay Range Flexibility* measure. The operations
 1390 associated with these measures at John Day Dam are as follows:

- 1391 • The operating range in April and May would be 263.5 to 265.0 feet NGVD29, compared to
 1392 262.5 to 264.0 feet NGVD29 for the No Action Alternative. This is the same flexibility in
 1393 elevation but shifted 1 foot higher than the range in the No Action Alternative.
- 1394 • The operating range in June through September would be 262.5 to 264.5 feet NGVD29,
 1395 compared to 262.5 to 264.0 feet NGVD29 for the No Action Alternative. This would be a
 1396 broader operating range than that for the No Action Alternative, allowing reservoir levels up
 1397 to 0.5 foot higher.

1398 The operating range for John Day Dam for Multi Objective Alternative 1 is shown in Figure 3-38.
 1399 The No Action Alternative operating range is shown for comparison purposes.



1400
 1401 **Figure 3-38. John Day Dam Operating Range for Multiple Objective Alternative 1**

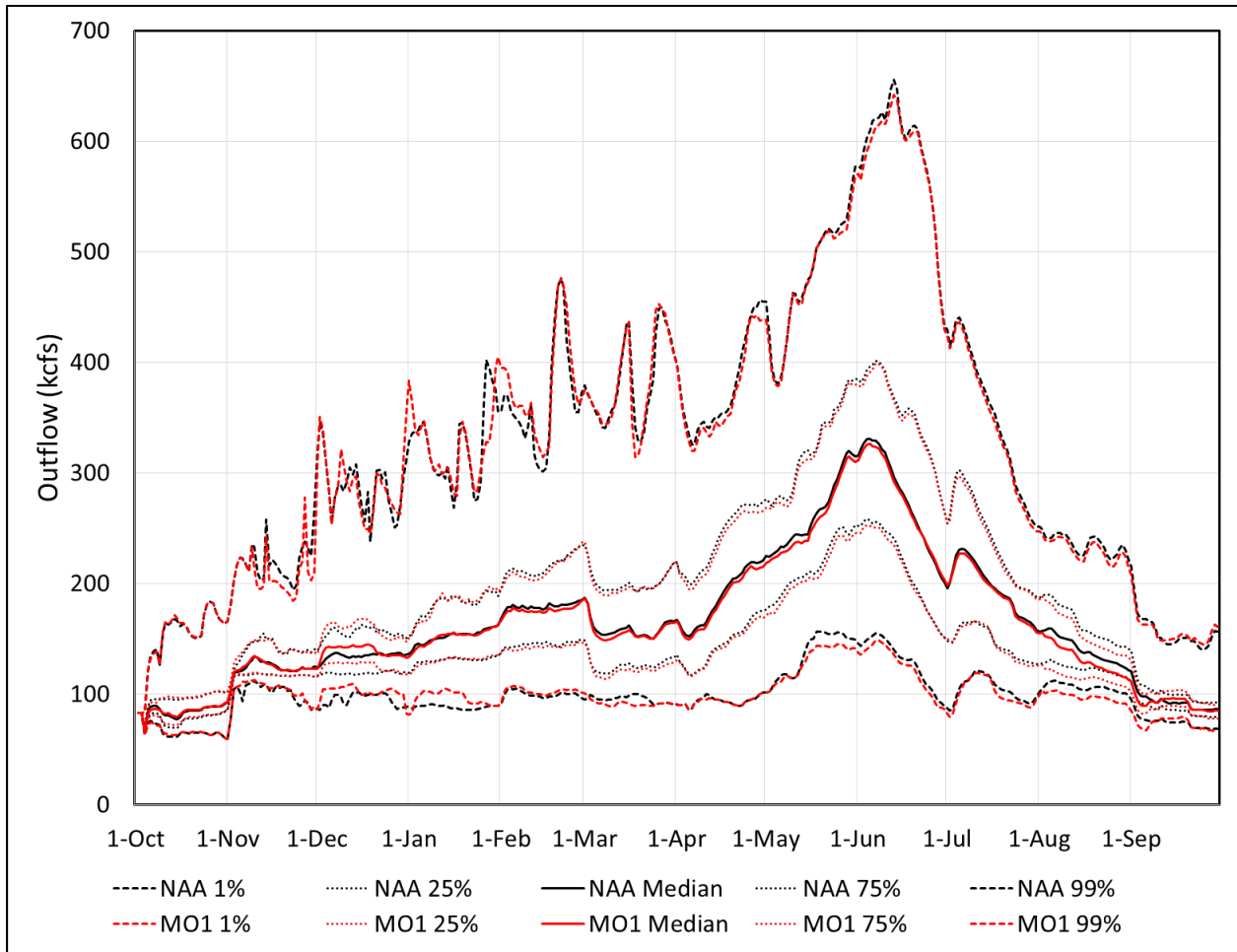
1402 Note: John Day may be operated between 257 feet and 268 feet NGVD29 for FRM purposes. These limits are not
 1403 shown on this figure in order to show greater detail in the vertical scale.

1404 **Lower Columbia River Flows**

1405 Under MO1, the *Modified Draft at Libby, December Libby Target Elevation, Update System FRM*
 1406 *Calculation, Planned Draft Rate at Grand Coulee, Winter System FRM Space, Lake Roosevelt*
 1407 *Additional Water Supply, Hungry Horse Additional Water Supply, Chief Joseph Dam Project*
 1408 *Additional Water Supply, Modified Dworshak Summer Draft, and Sliding Scale at Libby and*
 1409 *Hungry Horse* measures would cause changes in flow patterns in the lower Columbia River.

1410 At McNary Dam, the outflows under MO1 would differ from the No Action Alternative to
 1411 various extents through the water year. The magnitude and timing of differences in flow are
 1412 displayed in Figure 3-39. In general, flows in December under MO1 tend to be higher than those
 1413 for the No Action Alternative; flows in August under MO1 tend to be lower than those for the
 1414 No Action Alternative. There are slight differences in other months as well, but not as
 1415 pronounced as these 2 months.

1416 In addition to the daily flow values depicted in Figure 3-39, the monthly average outflows from
 1417 McNary Dam that would occur under MO1 were compared to those for the No Action
 1418 Alternative, and from which the following conclusions were drawn:

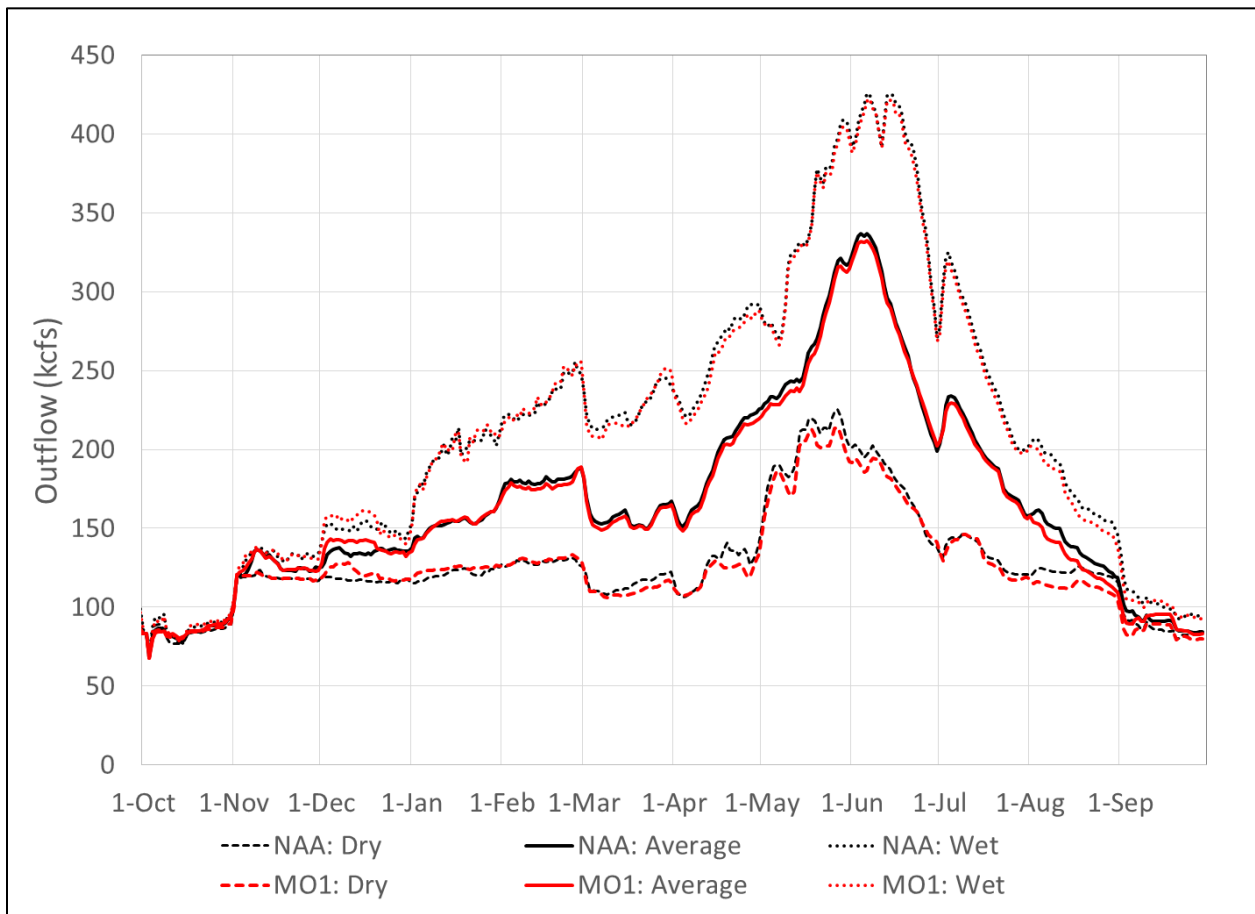


1419 **Figure 3-39. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 1**
 1420

- 1421 • In December, the median value of the monthly average outflow would increase by 4.5 kcfs.
- 1422 A combination of measures would cause this, with the *Winter System FRM Space* measure
- 1423 being the main reason for the flow increases.

- 1424 • In August, the median value of the monthly average outflow would decrease by 8.5 kcfs. A
- 1425 combination of measures would cause this. The *Modified Dworshak Summer Draft* measure
- 1426 at Dworshak Dam (modifying the timing of water releases in the summer), the *Lake*
- 1427 *Roosevelt Additional Water Supply* measure at Grand Coulee Dam (increasing the volume of
- 1428 water pumped from Lake Roosevelt into Banks Lake), the *Hungry Horse Additional Water*
- 1429 *Supply* measure on the Flathead River (reducing flows below Flathead Lake by
- 1430 approximately 0.5 kcfs), and the *Sliding Scale at Libby and Hungry Horse* measure at Libby
- 1431 Dam (changing the end of September target reservoir elevation) would all play a role in this
- 1432 flow reduction, as would several of the other measures.

1433 Finally, Figure 3-40 shows median hydrographs for McNary Dam outflow in dry, average, and
 1434 wet years. The figure provides another way to picture the effects described above, this time
 1435 categorized by water year type.



1436
 1437 **Figure 3-40. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 1438 **Alternative 1**

1439 The effects on McNary Dam outflow from MO1 would occur similarly, and for the same
1440 reasons, at John Day Dam, The Dalles Dam, and Bonneville Dam. Along the lower Columbia
1441 River, the median value of the average monthly flow for MO1 would be higher than the No
1442 Action Alternative in some months (for example, December), and lower in others (for example,
1443 August). The flow change patterns seen at the confluence of the Columbia and Snake Rivers
1444 continue downstream to other locations. This is seen in Table 3-18.

1445 **Table 3-18. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 1**
1446 **(as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcfs)	Columbia+Snake	83	122	134	151	181	157	188	260	288	199	140	91
	McNary	85	124	136	154	182	159	192	260	285	198	141	93
	John Day	85	125	140	156	185	165	198	267	288	197	141	93
	The Dalles	90	130	146	163	192	172	206	273	293	202	146	97
	Bonneville	91	135	152	170	199	179	213	275	296	204	149	99
	Columbia+Willamette	108	178	225	252	267	233	260	314	319	216	159	111
	Columiba+Cowlitz	115	196	257	282	295	255	283	334	336	226	165	117
Change (kcfs)	Columbia+Snake	0.4	-0.2	3.3	0.6	-2.5	-1.8	-4.4	-6.1	-3.4	-2.5	-8.3	-0.9
	McNary	0.5	0.0	4.5	0.5	-2.1	-2.0	-3.9	-6.0	-2.7	-2.0	-8.5	-1.1
	John Day	0.4	-0.1	3.8	0.0	-2.4	-1.9	-4.6	-6.7	-1.9	-2.0	-8.5	-0.9
	The Dalles	0.4	-0.2	3.5	0.1	-2.7	-1.8	-3.9	-6.7	-1.7	-1.9	-8.7	-1.0
	Bonneville	0.4	-0.5	3.5	0.4	-2.4	-2.4	-4.4	-6.4	-2.0	-2.0	-8.0	-1.3
	Columbia+Willamette	0.3	0.6	4.8	0.4	-3.9	-1.6	-4.6	-6.0	-1.7	-1.8	-8.0	-1.6
	Columiba+Cowlitz	0.3	0.4	5.1	0.3	-2.8	-2.3	-4.5	-5.2	-2.4	-1.6	-7.5	-1.7
Percent Change	Columbia+Snake	0%	0%	2%	0%	-1%	-1%	-2%	-2%	-1%	-1%	-6%	-1%
	McNary	1%	0%	3%	0%	-1%	-1%	-2%	-2%	-1%	-1%	-6%	-1%
	John Day	0%	0%	3%	0%	-1%	-1%	-2%	-2%	-1%	-1%	-6%	-1%
	The Dalles	0%	0%	2%	0%	-1%	-1%	-2%	-2%	-1%	-1%	-6%	-1%
	Bonneville	0%	0%	2%	0%	-1%	-1%	-2%	-2%	-1%	-1%	-5%	-1%
	Columbia+Willamette	0%	0%	2%	0%	-1%	-1%	-2%	-2%	-1%	-1%	-5%	-1%
	Columiba+Cowlitz	0%	0%	2%	0%	-1%	-1%	-2%	-2%	-1%	-1%	-5%	-1%

1447 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO1 flows lower than the No
1448 Action Alternative flows; green shading denotes MO1 flows higher than the No Action Alternative flows.

1449 **SUMMARY OF EFFECTS**

1450 In MO1, the largest changes in water levels occur at Libby, Grand Coulee, and Dworshak Dams.
1451 At Libby Dam, Lake Kocanusa water levels are less variable in the winter and spring, with
1452 notably deeper drafts in low forecast years and less-deep drafts in large forecast years. Lake
1453 Roosevelt water levels are notably lower in the winter due to additional winter FRM space, and
1454 slightly higher later in the year. Dworshak Reservoir water levels are lower in late June through
1455 mid-August, and then higher mid-August through September. Smaller but notable water level
1456 changes occur at Hungry Horse Reservoir, where additional water demands in the summer
1457 months result in slightly lower reservoir levels most of the year. Similarly, average water levels
1458 at John Day Dam and the lower Snake River projects are slightly higher in the spring and
1459 summer months due to increased forebay operating range flexibility.

1460 The largest impacts to river flow occur immediately below Libby, Grand Coulee, and Dworshak
1461 Dams, and total flow changes are largest below Grand Coulee Dam. At Libby, the largest
1462 changes are decreases in December and May in most years combined with more flow being
1463 released in January through March. Additional winter FRM space in Lake Roosevelt translates to
1464 notably higher December releases from Grand Coulee and an increased occurrence of high
1465 releases in the winter as the dam is operated to reduce winter peak flows and stages in the
1466 lower Columbia River near Portland. Water supply delivery increases from Grand Coulee and
1467 Chief Joseph Dams result in consistently lower spring and summer flows in the Columbia River
1468 downstream. Below Dworshak Dam, flows are higher late June and July, notably lower in
1469 August, and then higher in September. In the lower Columbia River, flows are slightly higher in
1470 December and slightly lower in the spring and summer months. With the exception of August,
1471 which would be more than 5 percent lower in most years, changes in average monthly flow
1472 through the lower Columbia River are within 3 percent of the No Action Alternative for all
1473 months for most years.

1474 **3.2.4.5 Multiple Objective Alternative 2**

1475 As the effects of MO2 are presented, they will be displayed along with the No Action
1476 Alternative to illuminate the timing and magnitude of differences in water conditions between
1477 it and the No Action Alternative. Similar to previous sections, the operational measure (or
1478 measures) from MO2 which would result in changes from the No Action Alternative are
1479 identified to the extent possible.

1480 It should be noted that the *Ramping Rates for Safety* measure in MO2 would allow for less
1481 restrictive ramping rates at all CRS projects, meaning that changes in outflow could be greater
1482 in magnitude than for the No Action Alternative. This measure was implemented to the extent
1483 possible in the hydroregulation modeling (ramping rates at Libby and Hungry Horse Dams were
1484 doubled) but it is not reflected in modeling at the other CRS projects. Effects on power
1485 generation and transmission are discussed in Section 3.7.3 of this EIS.

1486 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

1487 **Lake Koocanusa (Libby Dam Reservoir) Elevation**

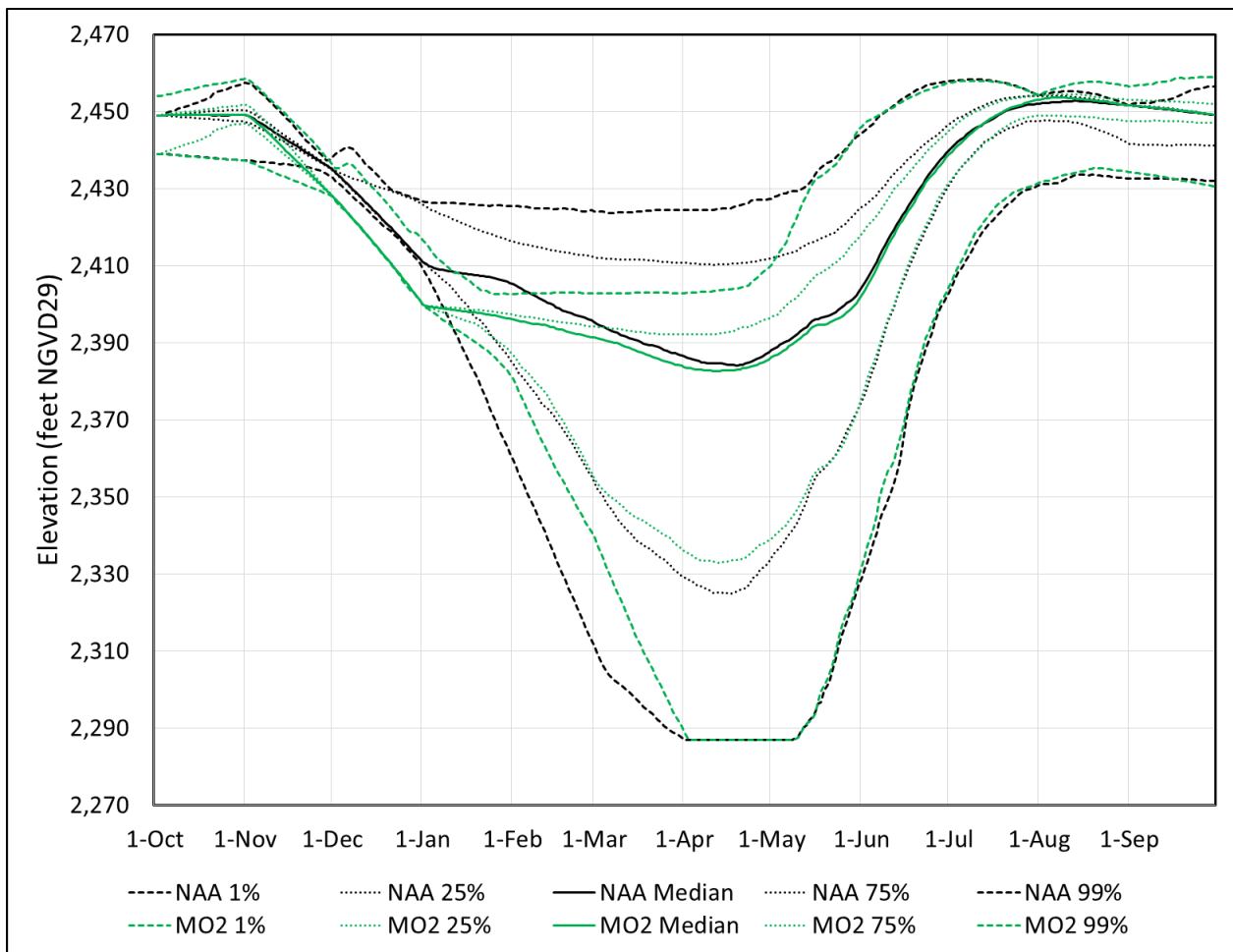
1488 Under MO2, the *Ramping Rates for Safety*, *Slightly Deeper Draft for Hydropower*, *Sliding Scale*
1489 *at Libby and Hungry Horse*, *Modified Draft at Libby*, and *December Libby Target Elevation*
1490 measures would have a direct effect on Libby Dam operations.

1491 Reservoir water levels in Lake Koocanusa would differ from the No Action Alternative, as shown
1492 in Figure 3-41.

1493 MO2 would generally have the same end-of-October reservoir elevation as the No Action
1494 Alternative. However, over the course of November and December, the reservoir elevations for
1495 MO2 would be lower than for the No Action Alternative due to the combination of the *Slightly*

1496 *Deeper Draft for Hydropower* measure with the *December Libby Target Elevation* measure,
 1497 resulting in an end-of-December elevation of 2,400 feet NGVD29 in most years.

1498 Through the remaining winter months and into the early spring, reservoir levels would
 1499 generally continue to be lower under MO2 than they would be for the No Action Alternative,
 1500 though this is not always the case as seen in the 99 percent exceedance and 75 percent
 1501 exceedance lines. The reservoir elevations that would occur in the winter and early spring are
 1502 driven by the prolonged effect of the lower end of December elevation (from the *Slightly*
 1503 *Deeper Draft for Hydropower* measure in combination with the *December Libby Target*
 1504 *Elevation* measure); the lower elevation permitted in April and May from the *Slightly Deeper*
 1505 *Draft for Hydropower* measure, and/or the *Modified Draft at Libby* measure. It should be noted
 1506 that MO2 targets a reservoir elevation of 2,400 feet NGVD29 at the end of December due to
 1507 the *Slightly Deeper Draft for Hydropower* measure, but uses draft targets in January, February,
 1508 and March set by an SRD (*Modified Draft at Libby* measure) designed to accommodate an end-
 1509 of-December elevation of 2,420 (NGVD29). The result of this combination of measures is that in
 1510 higher water supply years the reservoir is not drafted as deeply in January through March as
 1511 would be desired to achieve April FRM draft targets while striving for relatively stable outflow.



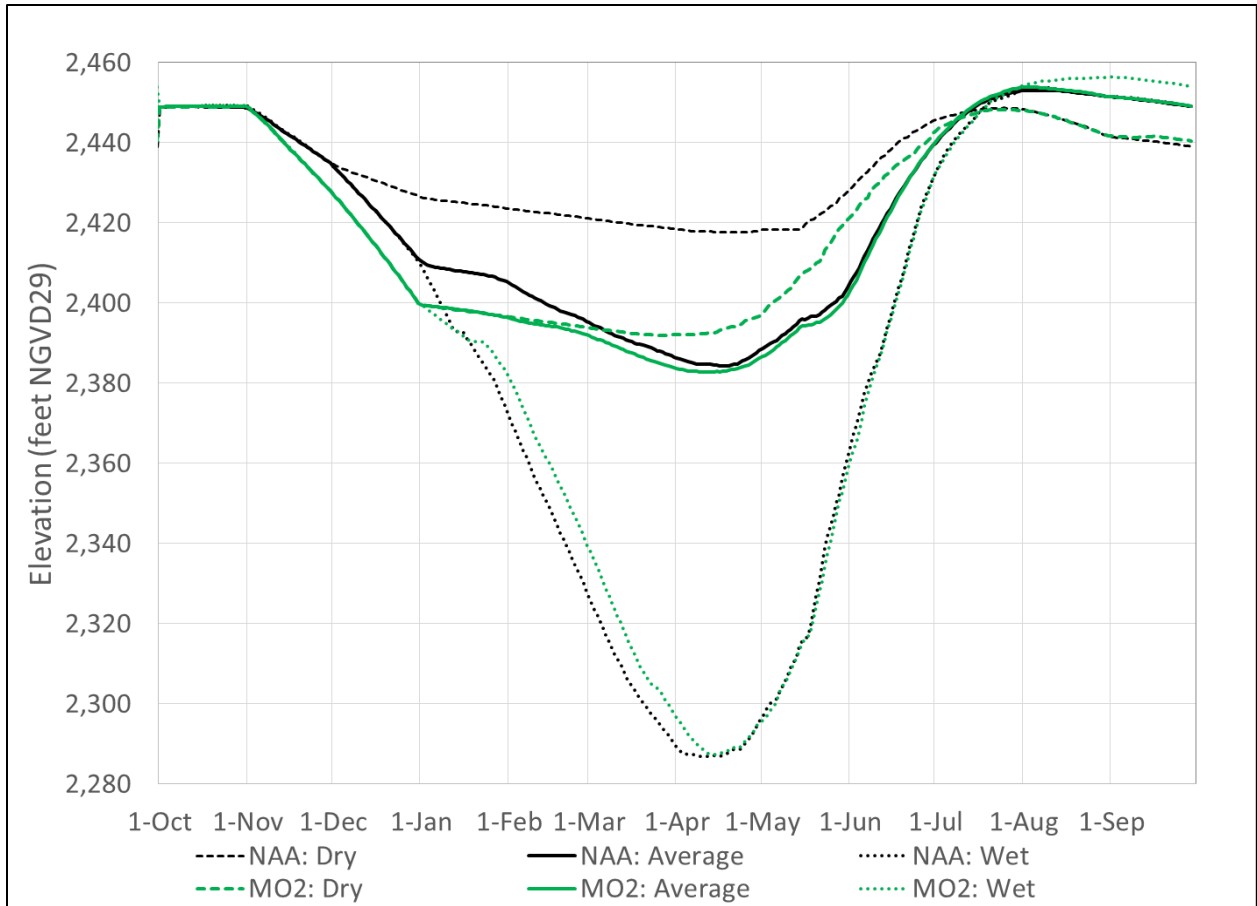
1512 **Figure 3-41. Lake Kocanusa Summary Hydrograph for Multiple Objective Alternative 2**
 1513

1514 By April or May, the reservoir would generally begin refilling. The modified refill operation
1515 called for in the *Modified Draft at Libby* measure would generally improve the probability of
1516 refilling the reservoir, though in the driest years the reservoir would have less success in
1517 refilling (as compared to the No Action Alternative) due to the lower winter and early spring
1518 reservoir elevations that would occur with the *Slightly Deeper Draft for Hydropower* measure.
1519 Overall, MO2 would have a 44 percent chance of the reservoir reaching elevation 2,454 feet
1520 NGVD29 or higher (within 5 feet of the full pool elevation of 2,459 feet NGVD29) by July 31, as
1521 compared to a 39 percent chance for the No Action Alternative. The peak reservoir elevation
1522 would usually be achieved in July or early August.

1523 During the months of August and September, the reservoir elevation for MO2 would generally
1524 be about 1 to 4 feet higher than for the No Action Alternative. The reason for this is the
1525 *Modified Draft at Libby* measure, which tends to increase the peak refill elevation, and the
1526 *Sliding Scale at Libby and Hungry Horse* measure which calls for a sliding scale end-of-
1527 September target elevation that would be dependent on the Libby Dam water supply forecast,
1528 rather than the system-wide water supply forecast at The Dalles. The *Sliding Scale at Libby and*
1529 *Hungry Horse* measure targets a higher elevation than the No Action Alternative in the wettest
1530 25 percent of years.

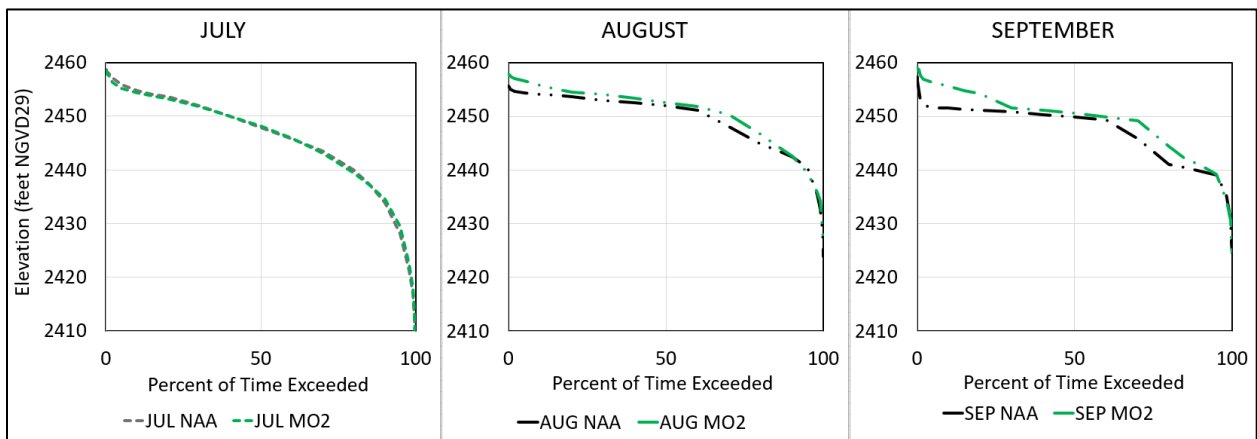
1531 As already discussed, the timing of and extent to which the reservoir elevation for MO2 would
1532 differ from the No Action Alternative would vary throughout the year. It is helpful to examine
1533 the changes that would occur based on the water year type, as shown in the median
1534 hydrographs for dry, average, and wet years in Figure 3-42. Dry years would see the most
1535 pronounced difference, with lower reservoir elevations beginning in November and December,
1536 and continuing through the winter and early spring, when they would be 20 to 25 feet lower
1537 than under the No Action Alternative. Average years would also have lower reservoir
1538 elevations, with the difference being most pronounced in the late fall and early winter months.
1539 Wet years would also differ, having lower reservoir elevations in November and December, and
1540 similar or higher elevations through the remainder of the water year.

1541 Finally, the three panels in Figure 3-43 show monthly elevation duration curves for July, August,
1542 and September, respectively. The curve for MO2 is plotted along with the curve for the No
1543 Action Alternative in each month. For July, the MO2 curve is virtually identical to the No Action
1544 Alternative. In August and September, the reservoir elevation under MO2 would tend to be the
1545 same or higher than the No Action Alternative. The higher elevations in late summer are
1546 attributable to the *Sliding Scale at Libby and Hungry Horse* measure, which has fewer years
1547 drafting to 2,439 feet NGVD29 than the No Action Alternative due to the change in forecast
1548 location, and the wettest years only needing a draft to 2,454 feet NGVD29.



1549
 1550
 1551

Figure 3-42. Lake Kocanusa Water Year Type Hydrographs for Multiple Objective Alternative 2



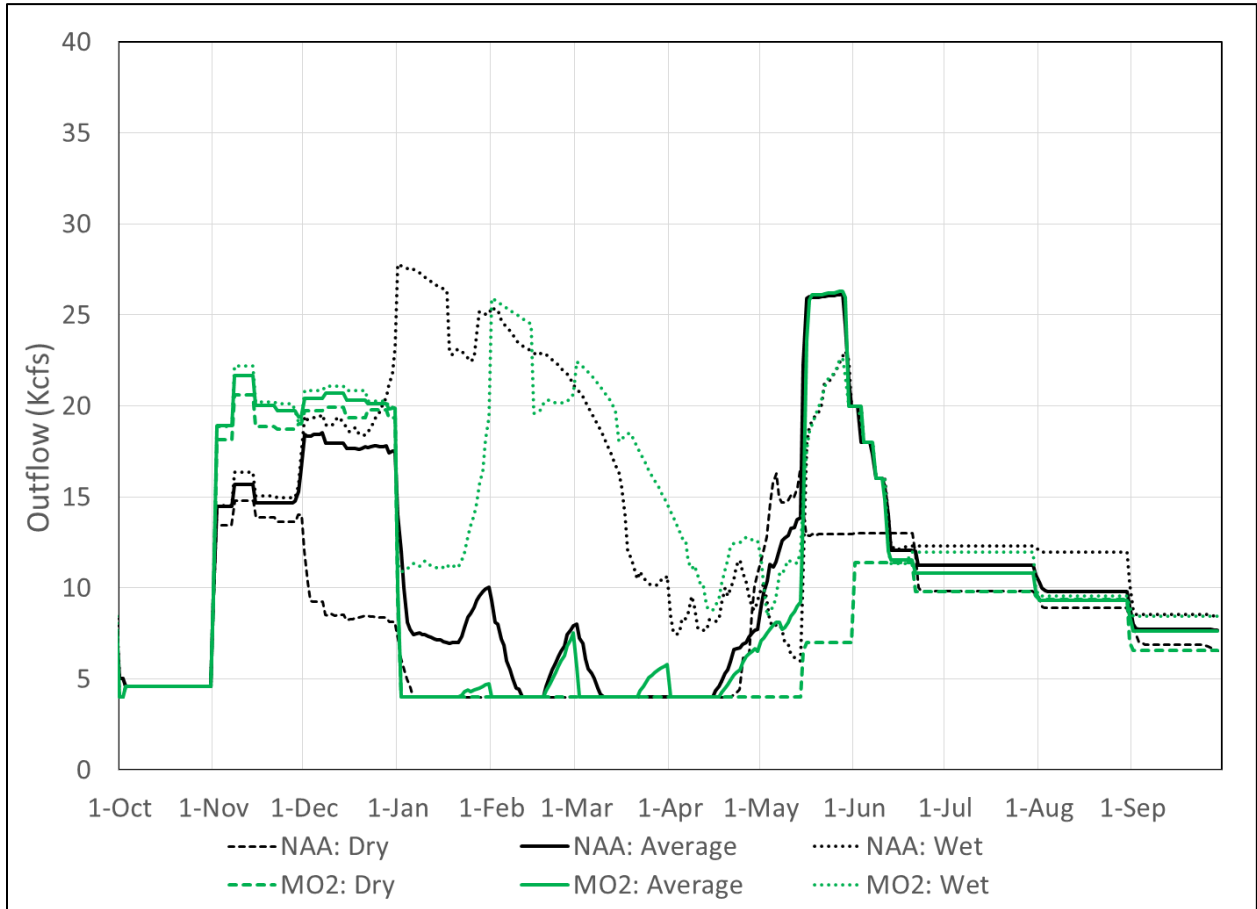
1552
 1553

Figure 3-43. Lake Kocanusa Summer Elevations for Multiple Objective Alternative 2

1554 Libby Dam Outflow

1555 Under MO2, the *Ramping Rates for Safety, Slightly Deeper Draft for Hydropower, Sliding Scale*
 1556 *at Libby and Hungry Horse, Modified Draft at Libby, and December Libby Target Elevation*
 1557 *measures* would have a direct effect on Libby Dam outflow. As seen in Figure 3-44, the change

1558 in outflows from the No Action Alternative varies throughout the year. Figure 3-44 shows
1559 median hydrographs for Libby Dam outflow in dry, average, and wet years.



1560
1561 **Figure 3-44. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective**
1562 **Alternative 2**

1563 Throughout the year, the *Ramping Rates for Safety* measure would allow less restrictive
1564 ramping rates, meaning that changes in outflow from Libby Dam (increases or decreases) could
1565 be greater in magnitude than for the No Action Alternative. This measure would not discernibly
1566 alter the monthly average outflow but could change the outflow for a few days following a
1567 sharp rise or drop in flow. It should be noted that the HEC-ResSim hydroregulation modeling
1568 does not incorporate hourly, daily, or weekly load shaping at any dam. Load shaping can cause
1569 fluctuations between higher and lower releases.

1570 The change in average monthly outflow throughout the water year is presented in Table 3-19.

1571 **Table 3-19. Libby Dam Monthly Average Outflow for Multiple Option Alternative 2 (as change**
 1572 **from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	4.9	23.5	22.0	27.1	25.8	23.0	20.8	22.7	22.6	22.9	17.8	12.0
		25%	4.7	16.2	18.9	18.3	20.0	12.2	9.9	19.2	17.1	14.3	12.1	8.8
		50%	4.7	14.3	17.7	8.8	6.3	5.5	7.0	16.4	14.2	11.5	10.3	7.9
		75%	4.7	12.0	9.9	5.6	4.0	4.0	4.4	14.0	12.9	9.0	9.0	6.8
		99%	4.7	7.0	8.2	4.3	4.0	4.0	4.0	11.6	8.8	7.1	7.1	6.0
MO2	Change (kcfs)	1%	0.5	0.4	4.4	-5.7	-0.1	0.0	-1.1	-1.3	0.4	0.3	-3.3	0.1
		25%	-0.1	5.6	1.8	-7.7	-0.7	2.0	-0.2	-1.4	-0.9	-0.7	-1.1	-0.3
		50%	-0.1	4.9	2.4	-3.7	-1.4	-0.6	-1.8	-1.1	-0.7	-0.8	-0.9	-0.4
		75%	-0.1	4.2	9.6	-0.9	0.0	0.0	-0.4	-5.2	-0.6	0.0	0.0	-0.6
		99%	-0.1	3.7	10.7	0.3	0.0	0.0	0.0	-6.3	-2.2	-0.5	-0.5	0.0
	Percent change	1%	10%	2%	20%	-21%	0%	0%	-5%	-6%	2%	1%	-19%	1%
		25%	-1%	35%	10%	-42%	-4%	17%	-2%	-7%	-5%	-5%	-9%	-3%
		50%	-1%	34%	14%	-42%	-22%	-11%	-26%	-7%	-5%	-7%	-9%	-5%
		75%	-1%	35%	97%	-16%	0%	0%	-9%	-37%	-4%	0%	0%	-8%
		99%	-1%	53%	130%	8%	0%	0%	0%	-54%	-25%	-7%	-7%	0%

1573 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
 1574 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.

1575 Average outflow from Libby Dam under MO2 would differ from the No Action Alternative:

- 1576 • In November and December, the monthly average outflows would increase. At the median
 1577 level, the increase in November would be 4.9 kcfs and the increase in December would be
 1578 2.4 kcfs. The December increases would be most pronounced in the lowest water supply
 1579 forecast years, with increases of 9.6 and 10.7 kcfs, respectively, at the 75 percent and 99
 1580 percent exceedance levels. The outflow increases are caused by the reservoir drafting to
 1581 elevation 2,400 feet NGVD29 in most years, the result of the *Slightly Deeper Draft for*
 1582 *Hydropower* measure in combination with the *December Libby Target Elevation* measure.
- 1583 • In January through March, monthly average outflows would generally be the same or lower
 1584 than the No Action Alternative. At the median level, they would decrease by 3.7, 1.4, and
 1585 0.6 kcfs, respectively.
- 1586 • Overall April and May median monthly average outflows would decrease by 1.8 and 1.1
 1587 kcfs, respectively, from the No Action Alternative. These changes are related to the
 1588 *Modified Draft at Libby* measure that would account for future volume releases and refill
 1589 the reservoir more aggressively.
- 1590 • In June and July, monthly average outflows would generally be lower than the No Action
 1591 Alternative. At the median level, they would decrease by 0.7 and 0.8 kcfs, respectively.
 1592 However, the very highest releases under MO2 would be greater than those for the No
 1593 Action Alternative.

- 1594 • In August and September, monthly average outflows would be lower than the No Action
- 1595 Alternative. At the median level, they would decrease by 0.9 and 0.4 kcfs, respectively. The
- 1596 *Sliding Scale at Libby and Hungry Horse* measure, which calls for a sliding scale end-of-
- 1597 September target elevation based on the Libby Dam water supply forecast, and a higher
- 1598 elevation target in the wettest 25 percent of years, is the primary cause of these changes.

1599 **Bonnors Ferry Flow**

1600 Under MO2, the *Ramping Rates for Safety, Slightly Deeper Draft for Hydropower, Sliding Scale*
 1601 *at Libby and Hungry Horse, Modified Draft at Libby, and December Libby Target Elevation*
 1602 measures would affect flows at Bonnors Ferry. In general, the flows would differ from the No
 1603 Action Alternative in much the same way as at Libby Dam, and for the same reasons. The
 1604 change in average monthly flow at Bonnors Ferry throughout the water year is presented in
 1605 Table 3-20.

1606 **Table 3-20. Bonnors Ferry Monthly Average Flow for Multiple Objective Alternative 2 (as**
 1607 **change from No Action Alternative)**

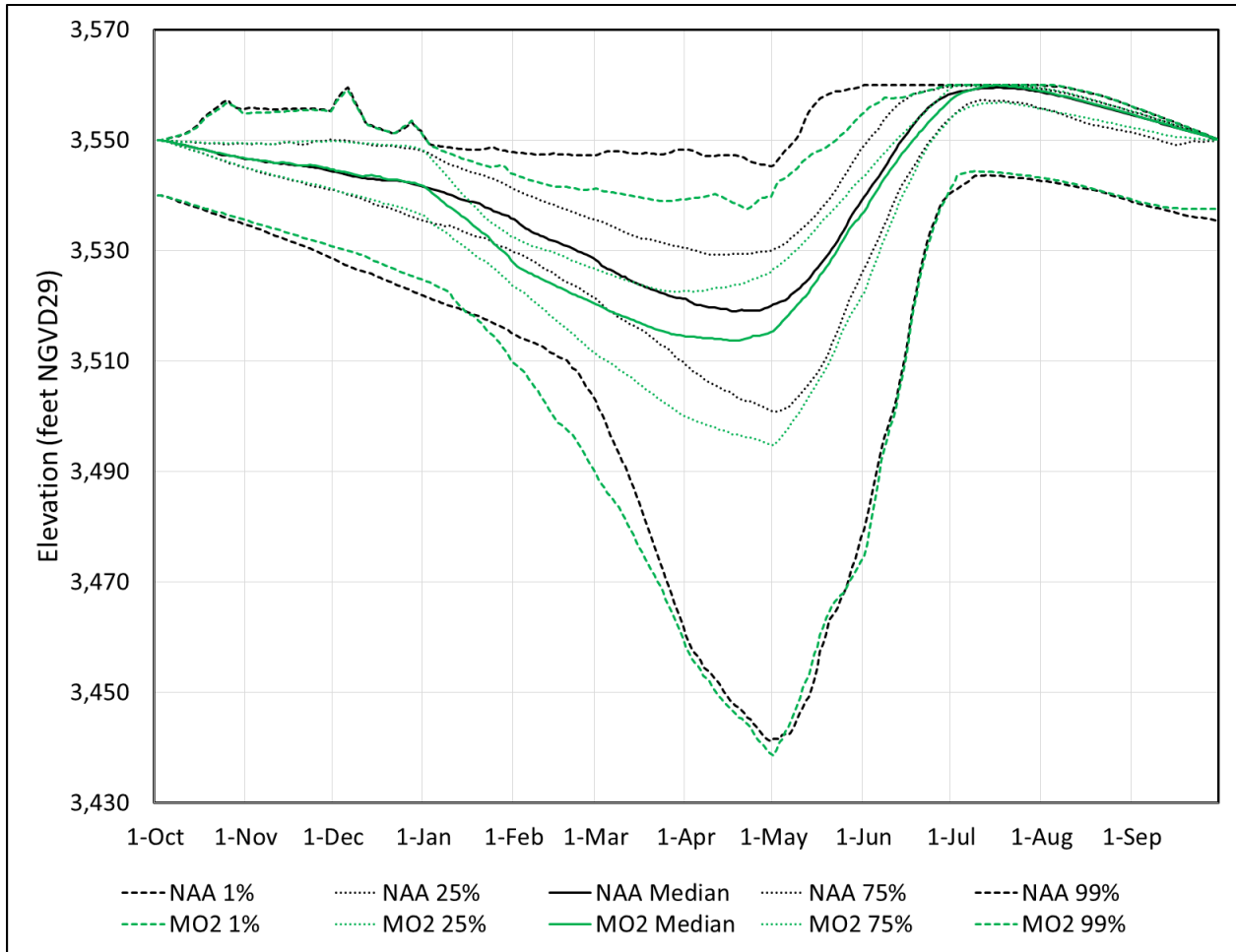
		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	9.0	26.6	29.2	31.3	29.7	27.5	30.4	40.8	40.7	27.2	19.0	13.3
		25%	6.1	18.1	20.7	21.0	23.2	15.3	19.4	34.3	27.8	17.3	13.3	9.7
		50%	5.6	15.4	18.9	10.4	8.5	8.4	14.6	31.1	23.8	14.6	11.4	8.6
		75%	5.4	13.0	11.4	6.5	5.1	5.9	10.2	27.6	20.3	11.8	9.9	7.4
		99%	5.1	7.7	9.0	5.1	4.5	4.9	7.0	18.3	12.6	9.0	8.1	6.7
MO2	Change (kcfs)	1%	0.3	1.6	1.7	-5.4	0.9	1.8	0.2	0.2	1.2	0.0	-3.5	0.7
		25%	-0.1	5.7	2.0	-8.6	-1.2	2.5	-0.6	-0.8	-0.7	-0.6	-1.1	-0.2
		50%	-0.1	4.8	2.6	-3.5	-1.3	-0.2	-1.1	-1.2	-0.7	-0.7	-0.8	-0.4
		75%	-0.1	4.4	9.0	-0.8	-0.1	-0.1	-0.5	-6.5	-0.7	-0.2	-0.3	-0.3
		99%	-0.1	3.8	10.7	0.3	0.0	0.0	0.0	-6.2	-2.9	-1.4	-0.9	-0.1
	Percent change	1%	4%	6%	6%	-17%	3%	7%	1%	0%	3%	0%	-18%	6%
		25%	-2%	32%	10%	-41%	-5%	17%	-3%	-2%	-2%	-4%	-8%	-2%
		50%	-1%	31%	14%	-34%	-16%	-2%	-7%	-4%	-3%	-5%	-7%	-5%
		75%	-1%	34%	79%	-12%	-2%	-2%	-5%	-24%	-3%	-2%	-3%	-4%
		99%	-1%	49%	119%	5%	0%	0%	0%	-34%	-23%	-15%	-11%	-2%

1608 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
 1609 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.

1610 **Hungry Horse Reservoir Elevation**

1611 Under MO2, several measures would have a direct effect on Hungry Horse Dam operations: the
 1612 *Ramping Rates for Safety, Slightly Deeper Draft for Hydropower, and Sliding Scale at Libby and*
 1613 *Hungry Horse* measures.

1614 Reservoir water levels would differ from the No Action Alternative, as shown in the summary
 1615 hydrograph, Figure 3-45.



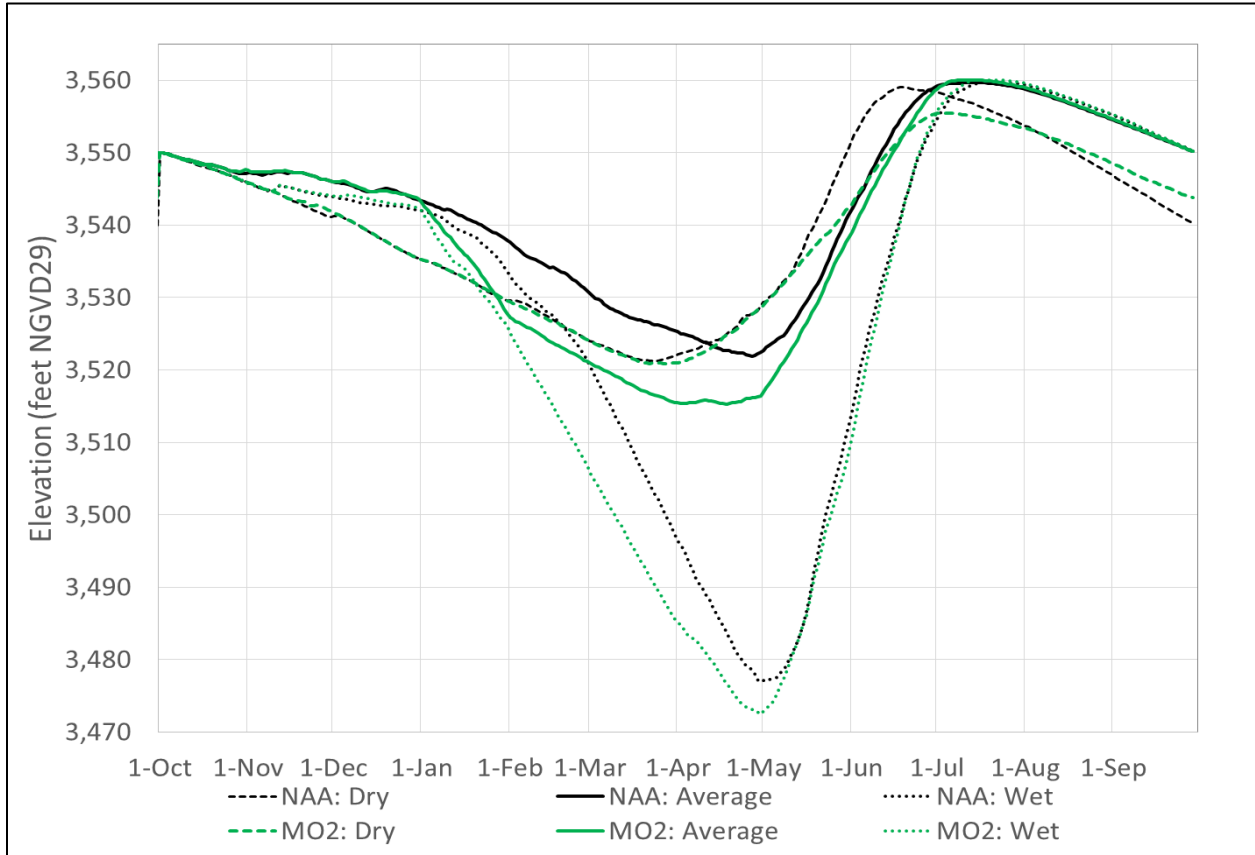
1616
 1617
 1618

Figure 3-45. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative 2

1619 From October through December, the reservoir elevations under MO2 would generally be the
 1620 same as the No Action Alternative. Starting in January the reservoir elevation would be lower
 1621 due to the *Slightly Deeper Draft for Hydropower* measure, which allows flexibility for additional
 1622 hydropower generation by drafting below the FRM elevations. Through the end of April, the
 1623 reservoir elevation would continue to be lower on account of the *Slightly Deeper Draft for*
 1624 *Hydropower* measure. During the months of January through April, the median daily reservoir
 1625 elevation for MO2 would be 4 to 8 feet lower than for the No Action Alternative.

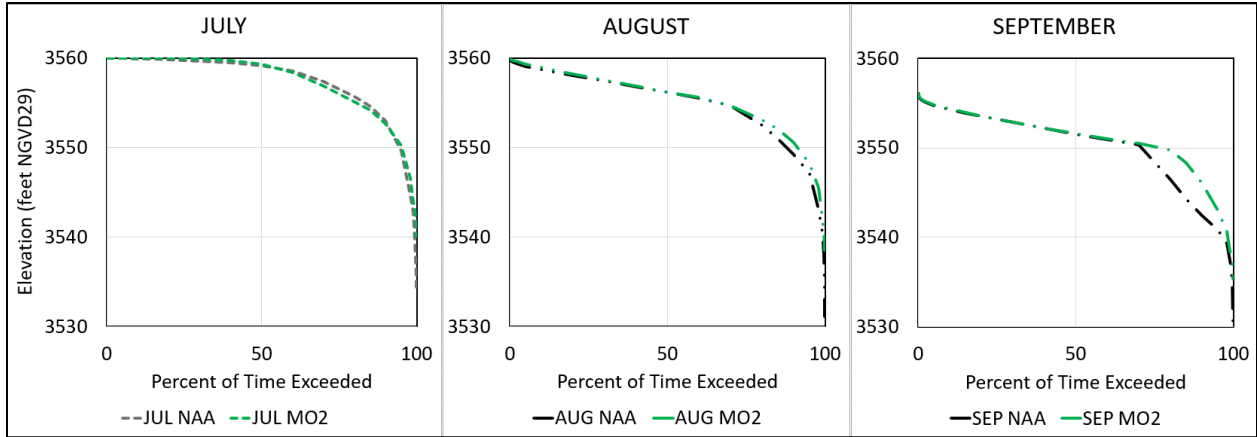
1626 Beginning in May the reservoir would begin to refill, but would remain lower than the No
 1627 Action Alternative, still on account of the *Slightly Deeper Draft for Hydropower* measure. By the
 1628 end of June, the reservoir elevation under MO2 would be close to that for the No Action
 1629 Alternative. Overall, there would be little difference in elevations in July, August, and
 1630 September, though the latter 2 months would have higher elevations in some years on account
 1631 of the *Sliding Scale at Libby and Hungry Horse* measure.

1632 Water levels at Hungry Horse Reservoir under MO2 would differ from the No Action Alternative
 1633 to varying extents, depending on the water year type. Median hydrographs of the reservoir
 1634 level for dry, average, and wet years are shown in Figure 3-46. This grouping by water year type
 1635 shows some effects that are not otherwise seen in the summary hydrograph presented in
 1636 Figure 3-46. Wet and average years have earlier, deeper drafts from January through April,
 1637 whereas the dry years show little difference from the No Action Alternative during this period.
 1638 From the late spring through July, the dry years show the most difference from the No Action
 1639 Alternative, with the dry years having lower reservoir elevations.



1640
 1641 **Figure 3-46. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective**
 1642 **Alternative 2**

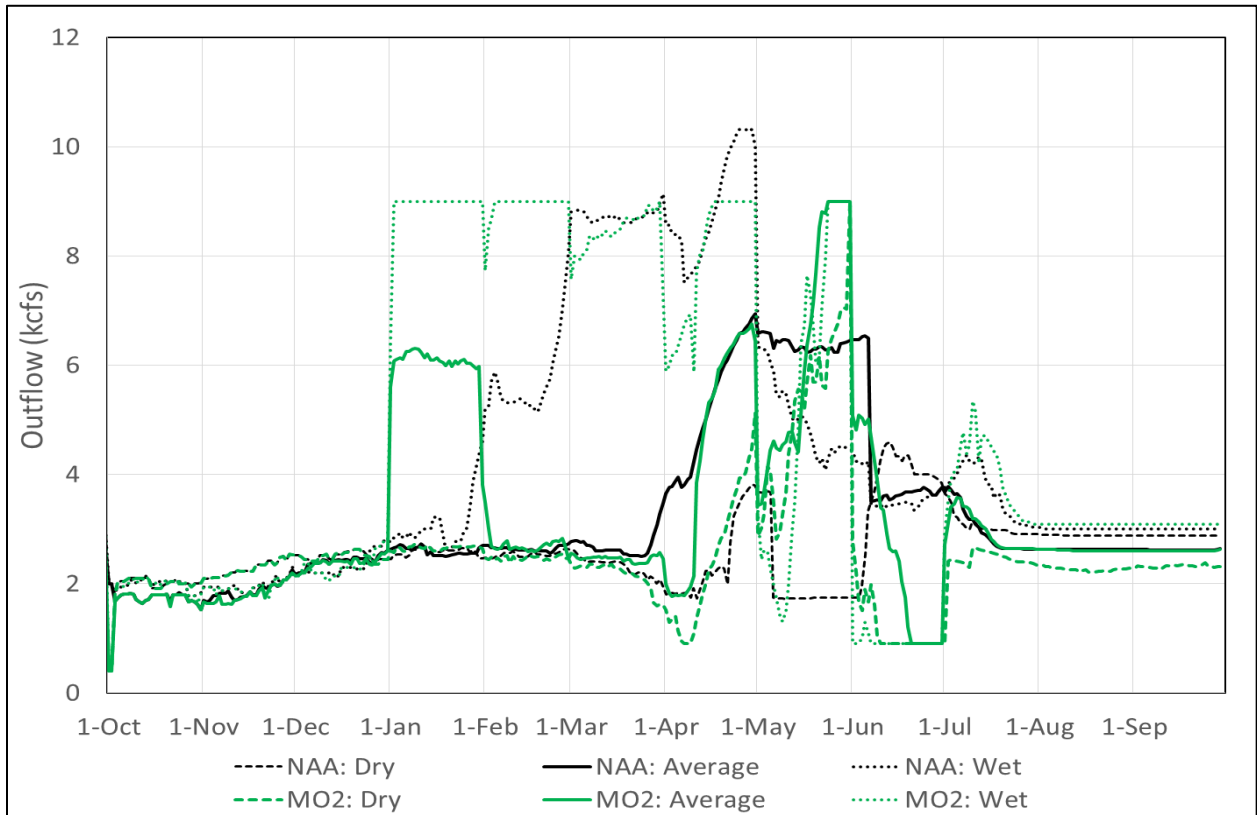
1643 Finally, the three panels in Figure 3-47 show Hungry Horse Reservoir elevation duration curves
 1644 for the months of July, August, and September, respectively. While other months have larger
 1645 differences, these three are shown because of interest in summer reservoir elevations. In
 1646 general, the reservoir levels in July would be the same for MO2 as for the No Action Alternative.
 1647 August and September would have higher elevations in some years, on account of the *Sliding*
 1648 *Scale at Libby and Hungry Horse* measure, which has fewer years drafting to 3,540 feet NGVD29
 1649 than the No Action Alternative due to the change in forecast location. For instance, the daily
 1650 reservoir elevation in September would be above elevation 3,550 feet NGVD29 about 77
 1651 percent of the time under MO2, whereas it would be above that elevation about 71 percent of
 1652 the time under the No Action Alternative.



1653
 1654 **Figure 3-47. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 2**

1655 **Hungry Horse Dam Outflow**

1656 Under MO2, the *Ramping Rates for Safety, Slightly Deeper Draft for Hydropower, and Sliding*
 1657 *Scale at Libby and Hungry Horse* measures would have a direct effect on Hungry Horse Dam
 1658 outflows. The outflows would differ from the No Action Alternative depending on the time of
 1659 year. Figure 3-48 shows median hydrographs for Hungry Horse Dam outflow in dry, average,
 1660 and wet years.



1661
 1662 **Figure 3-48. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 1663 **Alternative 2**

1664 The change in average monthly outflow from Hungry Horse Dam throughout the water year is
1665 presented in Table 3-21.

1666 **Table 3-21. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 2**
1667 **(as change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	2.5	4.7	6.9	7.1	11.5	14.5	15.6	9.6	10.7	6.9	4.4	4.4
		25%	2.2	2.4	2.7	3.1	4.0	5.7	8.1	7.0	6.1	4.2	3.1	3.1
		50%	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7
		75%	1.4	1.4	2.1	2.3	2.4	2.2	3.1	4.1	3.2	2.6	2.4	2.4
		99%	0.8	0.8	1.6	2.0	1.7	1.5	1.7	1.7	1.7	1.7	1.8	1.9
MO2	Change (kcfs)	1%	0.1	-0.8	-0.5	2.1	-0.3	-1.8	-2.7	0.3	0.1	0.0	-0.7	-0.7
		25%	-0.1	0.0	0.0	5.6	2.0	-0.5	-1.4	0.0	-1.5	-0.1	-0.1	-0.1
		50%	-0.1	0.0	0.0	2.8	0.1	-0.2	-0.9	-0.1	-1.6	-0.3	0.0	0.0
		75%	-0.1	0.0	0.0	0.4	0.0	-0.2	-0.4	0.1	-1.6	-0.3	-0.1	-0.1
		99%	0.1	0.2	0.0	0.1	0.1	-0.2	-0.5	0.4	-0.6	-0.1	-0.2	-0.2
	Percent change	1%	3%	-17%	-7%	29%	-2%	-13%	-17%	3%	1%	-1%	-15%	-15%
		25%	-5%	-1%	0%	179%	50%	-8%	-17%	-1%	-25%	-3%	-4%	-4%
		50%	-6%	-2%	-1%	108%	2%	-8%	-17%	-2%	-37%	-10%	-1%	-1%
		75%	-10%	0%	-1%	15%	-1%	-8%	-12%	3%	-50%	-10%	-5%	-4%
		99%	9%	27%	0%	6%	8%	-14%	-32%	22%	-33%	-5%	-8%	-11%

1668 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
1669 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.

1670 For most of the year, outflow from Hungry Horse Dam would differ from that of the No Action
1671 Alternative due to the *Slightly Deeper Draft for Hydropower* measure, which drafts the reservoir
1672 deeper starting in January for increased hydropower generation.

- 1673 • The greatest increase in outflows would occur in January. There would be an increase of 2.8
1674 kcfs in the median average monthly flow that month, at a time when the reservoir would
1675 typically be releasing 3 to 4 kcfs in the No Action Alternative to meet the Columbia Falls
1676 minimum flow.
- 1677 • In February, average monthly outflow at the 25 percent exceedance level would increase by
1678 2.0 kcfs, again due to the *Slightly Deeper Draft for Hydropower* measure.
- 1679 • In March and April, the average monthly outflow would be lower. This is because by the end
1680 of February, the *Slightly Deeper Draft for Hydropower* measure would generally have the
1681 reservoir 8 to 12 feet lower than for the No Action Alternative. Consequently, less drafting
1682 would be needed in March and April to meet reservoir elevation objectives in the spring
1683 (notably the April 10 elevation objective). The median value of the monthly average outflow
1684 in March and April decrease by 0.2 and 0.9 kcfs, respectively. At the higher flow levels (the
1685 25 percent and 1 percent exceedance levels), the decreases would be greater.
- 1686 • The late spring and early summer would also have lower outflows. The monthly average
1687 outflow in June and July would decrease by 1.6 and 0.3 kcfs, respectively.

1688 Throughout the year, the *Ramping Rates for Safety* measure would allow for less restrictive
1689 ramping rates, meaning that changes in outflow from Hungry Horse Dam (increases or
1690 decreases) could be greater in magnitude than for the No Action Alternative. This measure
1691 would not discernibly alter the monthly average outflow, but could change the outflow for a
1692 few days following a sharp rise or drop in flow. It should be noted that the HEC-ResSim
1693 hydroregulation modeling does not incorporate hourly, daily, or weekly load shaping at dams,
1694 including Hungry Horse Dam.

1695 **Columbia Falls Flow**

1696 Under MO2, the *Ramping Rates for Safety*, *Slightly Deeper Draft for Hydropower*, and *Sliding*
1697 *Scale at Libby and Hungry Horse* measures would affect flows at Columbia Falls. The change in
1698 average monthly flow at Columbia Falls throughout the water year, as compared to the No
1699 Action Alternative, is presented in Table 3-22.

1700 **Table 3-22. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 2 (as**
1701 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcf)	1%	8.9	14.4	14.8	11.0	14.2	17.4	30.5	38.0	43.2	23.9	8.8	8.7
		25%	4.0	4.2	4.5	5.0	5.8	7.9	15.9	29.7	31.5	15.1	6.9	5.4
		50%	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7
		75%	3.6	3.6	3.6	3.6	3.6	3.7	8.5	21.4	20.0	8.4	4.9	4.2
		99%	3.5	3.5	3.5	3.5	3.5	3.5	5.4	15.7	12.4	5.5	3.9	3.6
MO2	Change (kcf)	1%	0.1	-0.9	-0.5	2.4	0.0	-1.8	-3.6	0.6	-0.9	0.6	0.0	-0.6
		25%	-0.1	0.1	0.0	5.0	1.9	-0.5	-1.1	-0.8	-1.4	0.0	0.0	0.0
		50%	-0.1	0.0	0.0	3.4	0.4	-0.4	-0.8	0.2	-1.8	-0.3	-0.2	-0.1
		75%	-0.1	0.0	0.0	0.0	-0.1	-0.2	-0.6	-0.1	-1.5	-0.3	-0.3	-0.3
		99%	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.6	-0.1	-1.9	-0.1	-0.2	-0.1
	Percent change	1%	1%	-6%	-3%	22%	0%	-11%	-12%	2%	-2%	2%	0%	-7%
		25%	-3%	1%	-1%	100%	33%	-6%	-7%	-3%	-4%	0%	-1%	-1%
		50%	-4%	0%	0%	90%	11%	-9%	-6%	1%	-7%	-3%	-3%	-2%
		75%	-3%	0%	0%	0%	-2%	-6%	-7%	-1%	-7%	-3%	-6%	-6%
		99%	-4%	0%	0%	-1%	-2%	-3%	-11%	-1%	-15%	-2%	-5%	-3%

1702 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
1703 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.

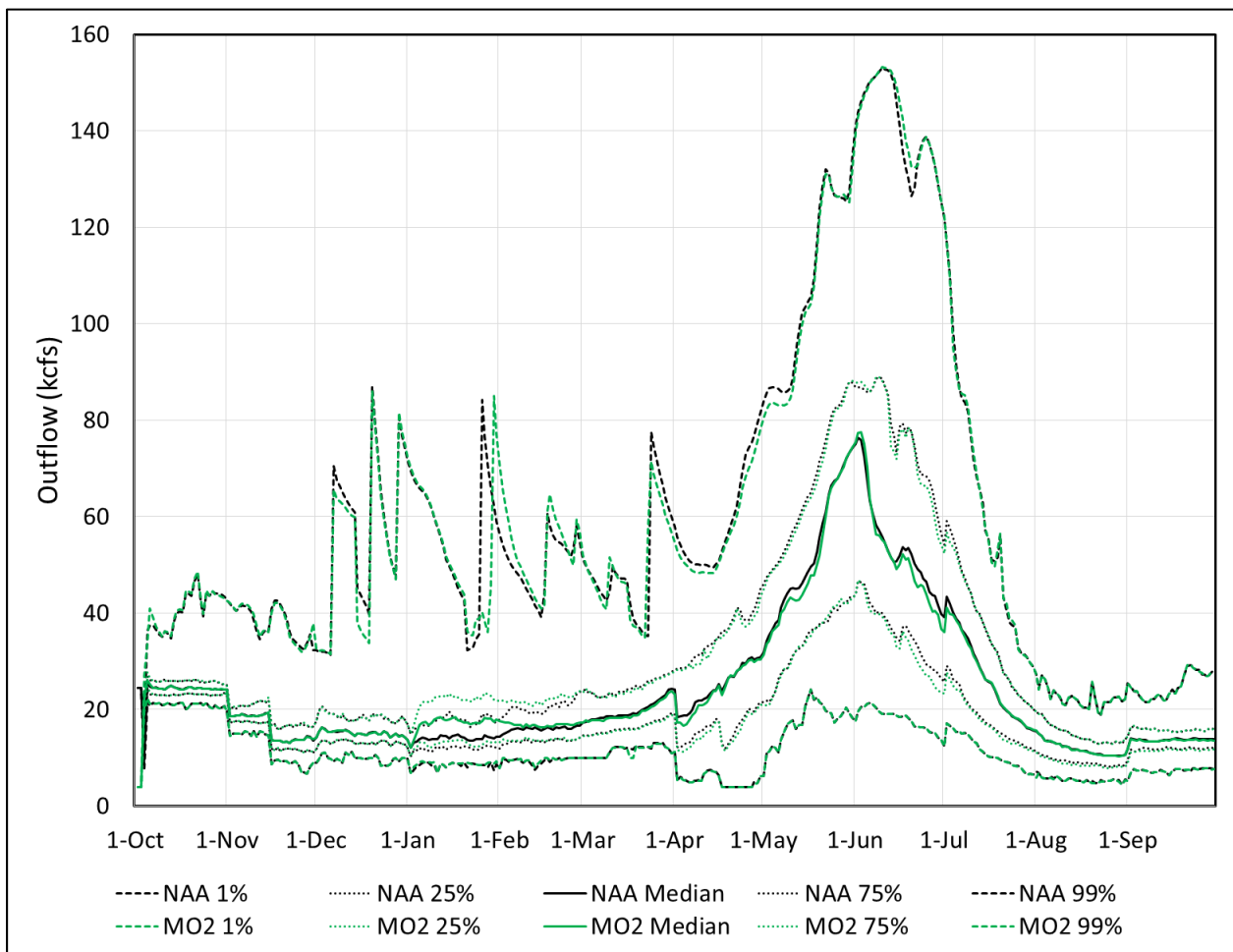
1704 **Lake Pend Oreille Elevation**

1705 Under MO2, there are no measures that would have a direct effect on the level of Lake Pend
1706 Oreille. The operational changes at Hungry Horse Dam from the *Slightly Deeper Draft for*
1707 *Hydropower* and *Sliding Scale at Libby and Hungry Horse* measures would translate
1708 downstream (as flow changes) and pass through Lake Pend Oreille. The flow changes would not
1709 impact the annual peak reservoir levels and would not change the timing of refill or drawdown.

1710 Thus, there would not be any noticeable difference in the level of Lake Pend Oreille as
 1711 compared to the No Action Alternative.

1712 **Albeni Falls Outflow**

1713 Under MO2, the flow changes caused by the *Slightly Deeper Draft for Hydropower* and *Sliding*
 1714 *Scale at Libby and Hungry Horse* measures at Hungry Horse Dam would translate downstream
 1715 and pass through Lake Pend Oreille, resulting in changed outflows from Albeni Falls Dam as
 1716 compared to the No Action Alternative. This is seen in the Albeni Falls Dam outflow summary
 1717 hydrograph in Figure 3-49. The most pronounced difference is seen during January and early
 1718 February, when outflows would generally be higher due to the *Slightly Deeper Draft for*
 1719 *Hydropower* measure.



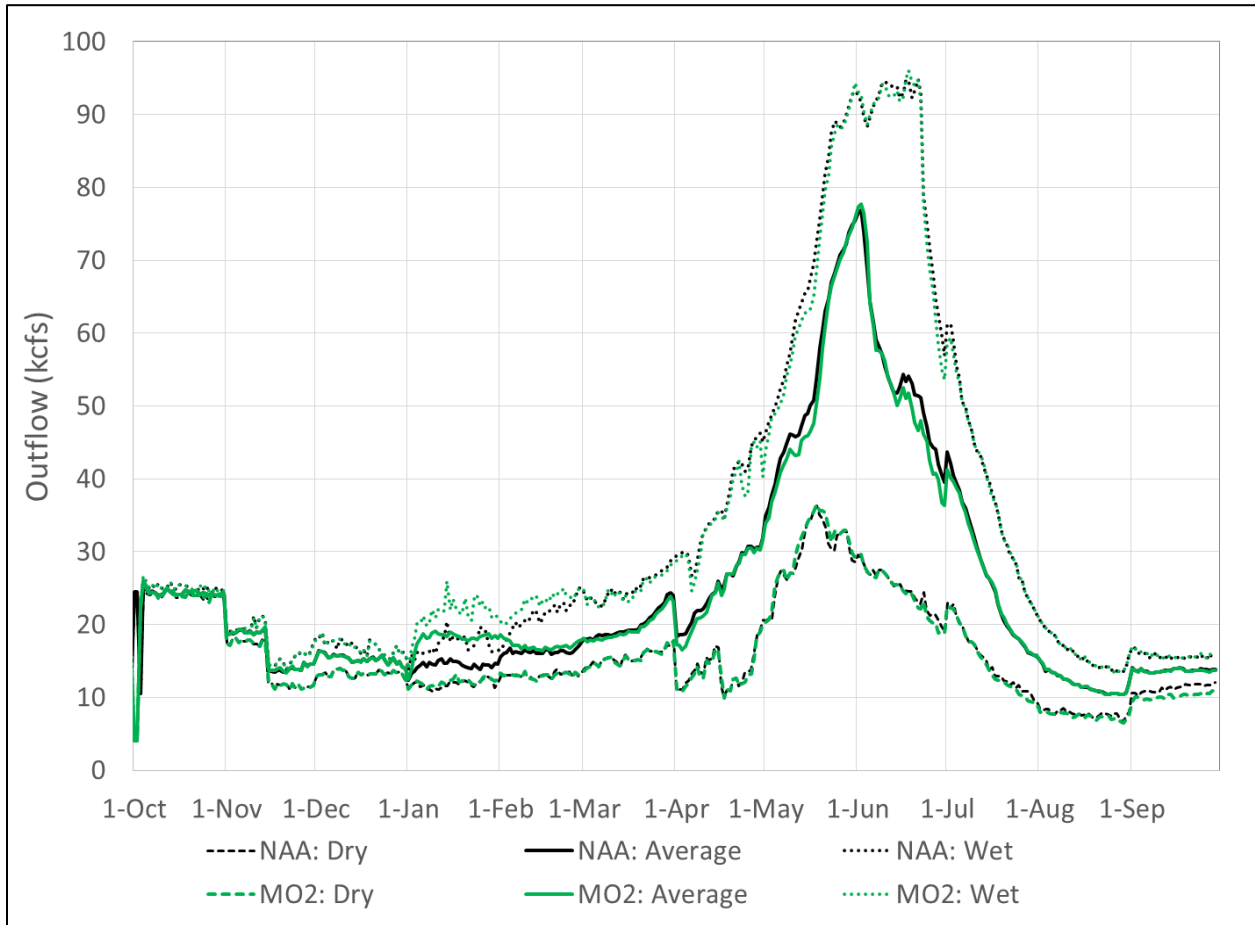
1720 **Figure 3-49. Albeni Falls Dam Outflow Summary Hydrograph for Multiple Objective**
 1721 **Alternative 2**
 1722

1723 The *Slightly Deeper Draft for Hydropower* measure at Hungry Horse Dam, as well as the *Sliding*
 1724 *Scale at Libby and Hungry Horse* measure, would affect the monthly average outflow from
 1725 Albeni Falls Dam, but to a lesser degree than at Hungry Horse Dam or Columbia Falls. This is
 1726 shown in Table 3-23.

1727 **Table 3-23. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 2 (as**
1728 **change from No Action Alternative)**

Location		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcfs)	Hungry Horse	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7
	Columbia Falls, MT	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7
	Albeni Falls	23.7	16.7	15.3	14.5	16.6	19.8	25.2	50.7	55.6	27.4	12.0	13.7
Change (kcfs)	Hungry Horse	-0.1	0.0	0.0	2.8	0.1	-0.2	-0.9	-0.1	-1.6	-0.3	0.0	0.0
	Columbia Falls, MT	-0.1	0.0	0.0	3.4	0.4	-0.4	-0.8	0.2	-1.8	-0.3	-0.2	-0.1
	Albeni Falls	-0.9	-0.1	0.0	3.2	1.0	-0.3	-0.8	-1.2	-1.4	-0.3	-0.1	-0.3
Percent Change	Hungry Horse	-6%	-2%	-1%	108%	2%	-8%	-17%	-2%	-37%	-10%	-1%	-1%
	Columbia Falls, MT	-4%	0%	0%	90%	11%	-9%	-6%	1%	-7%	-3%	-3%	-2%
	Albeni Falls	-4%	-1%	0%	22%	6%	-2%	-3%	-2%	-3%	-1%	-1%	-2%

1729 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
1730 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.



1731 **Figure 3-50. Albeni Falls Dam Outflow Water Year Type Hydrographs for Multiple Objective**
1732 **Alternative 2**
1733

1734 In January, the median value of the monthly average outflow from Albeni Falls Dam would be
1735 3.2 kcfs higher than the No Action Alternative. In February, it would be 1.0 kcfs higher than the
1736 No Action Alternative. Following that, the months of March, April, May, and June would all have

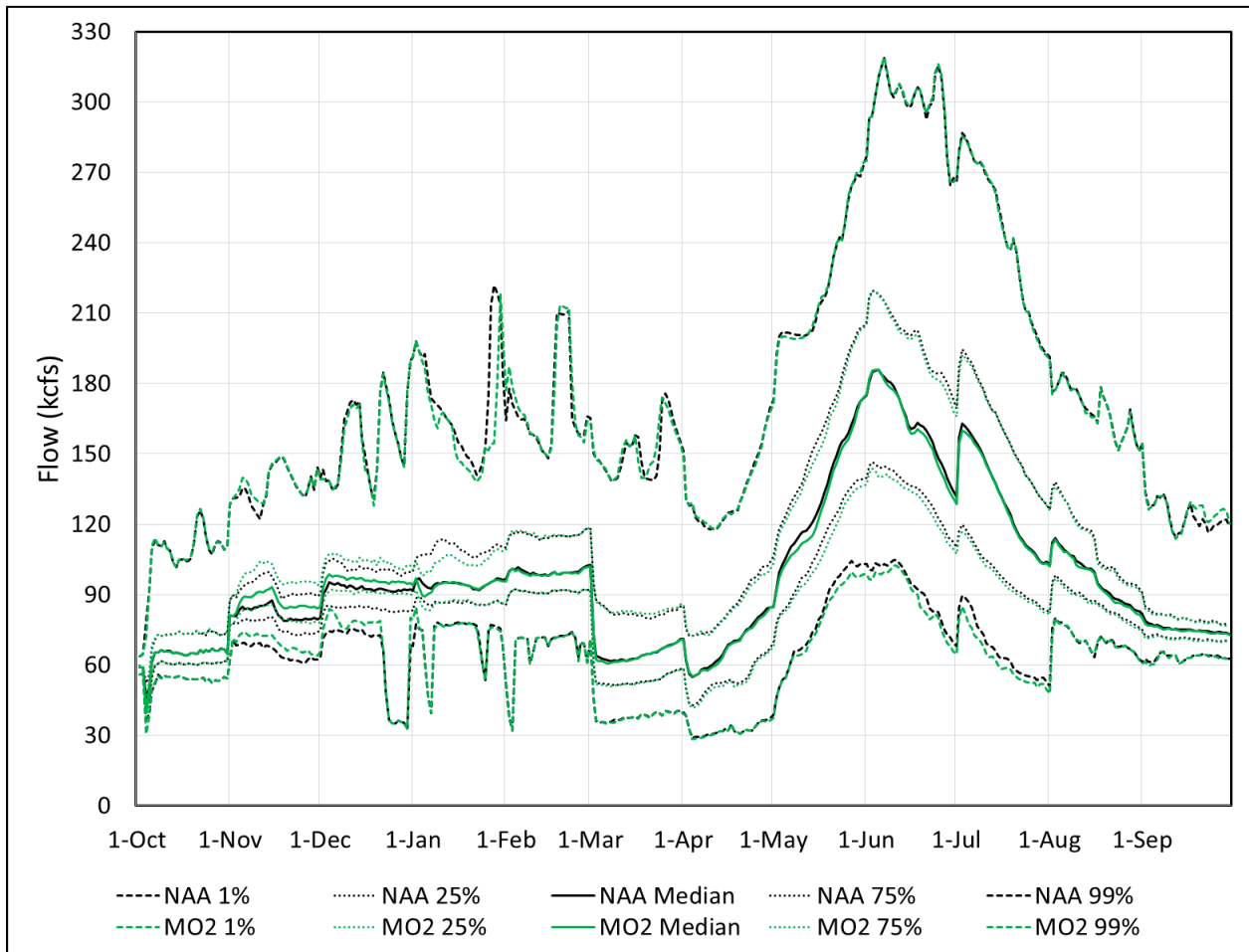
1737 lower outflows. The January to February flow increases and the March to June flow decreases
 1738 are all attributable to the *Slightly Deeper Draft for Hydropower* measure at Hungry Horse Dam.

1739 The median outflow hydrographs shown in Figure 3-50 are useful for understanding how the
 1740 Albeni Falls Dam outflow under MO2 would differ from the No Action Alternative in different
 1741 types of years. Average and wet years would have higher outflows in January, attributable to
 1742 the *Slightly Deeper Draft for Hydropower* measure at Hungry Horse Dam. Higher outflows
 1743 would also occur through most of February in wet years, again attributable to the *Slightly*
 1744 *Deeper Draft for Hydropower* measure.

1745 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

1746 **Columbia River Flow Upstream of Grand Coulee Dam**

1747 Under MO2, the *Slightly Deeper Draft for Hydropower*, *Sliding Scale at Libby and Hungry Horse*,
 1748 *Modified Draft at Libby*, and *December Libby Target Elevation* measures would affect Columbia
 1749 River flow upstream of Grand Coulee Dam. Figure 3-51 shows flows near RM 748 (just
 1750 downstream of the U.S.-Canada border, about 151 river miles upstream of Grand Coulee Dam).



1751 **Figure 3-51. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 2**
 1752

1753 Figure 3-51 characterizes the timing and magnitude of flow changes between the No Action
1754 Alternative and MO2 due to the combined effect of measures at Libby and Hungry Horse Dams.
1755 Changes in flow between MO2 and the No Action Alternative would be most noticeable in
1756 November, December, and January. In November, the median flow for MO2 would be about 5
1757 kcfs higher than for the No Action Alternative, primarily due to the *Slightly Deeper Draft for*
1758 *Hydropower* measure at Libby Dam. In December, flow would be about 4 kcfs higher than for
1759 the No Action Alternative. This is primarily attributable to the combined effect of the *December*
1760 *Libby Target Elevation* and *Slightly Deeper Draft for Hydropower* measures at Libby Dam. In
1761 January, flows would generally be the same or lower due to the combined effect of flow
1762 changes at Libby and Hungry Horse Dams. Libby Dam would already have a lower reservoir
1763 elevation at the end of December, so less drafting would occur in January to reach its end of
1764 January FRM elevation. At the same time, Hungry Horse outflows in January would generally be
1765 higher due to power drafts at that project occurring as part of the *Slightly Deeper Draft for*
1766 *Hydropower* measure.

1767 **Lake Roosevelt (Grand Coulee Dam Reservoir) Elevation**

1768 Under MO2, the *Slightly Deeper Draft for Hydropower*, *Update System FRM Calculation*,
1769 *Planned Draft Rate at Grand Coulee*, and *Winter System FRM Space* measures would influence
1770 reservoir elevations at Lake Roosevelt.

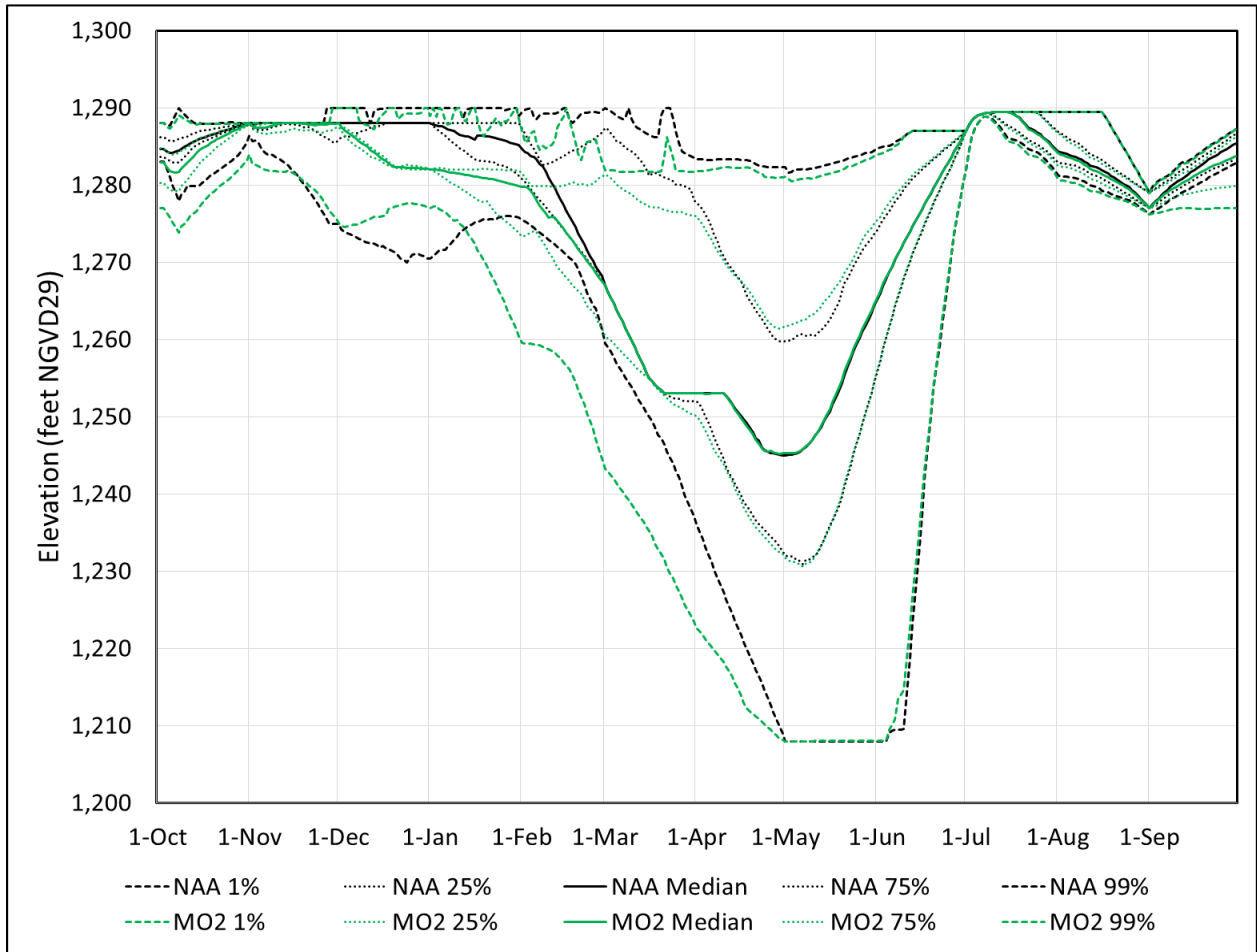
1771 In addition to the measures listed above, the *Slightly Deeper Draft for Hydropower*, *Sliding Scale*
1772 *at Libby and Hungry Horse*, *Modified Draft at Libby*, and *December Libby Target Elevation*
1773 measures would affect the inflow to Grand Coulee Dam. The hydroregulation modeling
1774 performed for MO2 incorporates all of these measures, but because each measure was not
1775 evaluated in isolation from the others, drawing a direct linkage between a single measure and
1776 an effect is not always possible. The effects that would occur from a measure or combination of
1777 measures are identified and discussed to the extent possible.

1778 Reservoir water levels in Lake Roosevelt under MO2 would differ from the No Action
1779 Alternative, as shown in the summary hydrograph, Figure 3-52.

1780 Under MO2, the reservoir elevation would be lower in October, December, January, and
1781 February in virtually all years, as compared to the No Action Alternative. During the remainder
1782 of the winter and through the early spring, the reservoir level would also generally be the same
1783 or lower than the No Action Alternative.

1784 The lower reservoir elevations in October are primarily caused by the *Slightly Deeper Draft for*
1785 *Hydropower* measure, which includes a minimum elevation of 1,283 feet NGVD29 at the end of
1786 October. (In the No Action Alternative, the target elevation of 1,283 feet NGVD29 is for the end
1787 of September for resident fish considerations.) From mid-December through January, the
1788 median monthly reservoir elevation would be about 5 feet lower under MO2 than for the No
1789 Action Alternative. This is primarily due to the *Winter System FRM Space* measure, which would
1790 increase the space available at Grand Coulee Dam for FRM in the winter months when rain-
1791 induced floods may occur as well as the *Slightly Deeper Draft for Hydropower* measure, which

1792 drafts the project more deeply for hydropower in January of the wettest years. In February, the
 1793 reservoir would be lower than the No Action Alternative, primarily due to the *Slightly Deeper*
 1794 *Draft for Hydropower* and *Planned Draft Rate at Grand Coulee* measures. By March 1, the
 1795 median reservoir levels for MO2 realign with those in the No Action Alternative and match
 1796 almost exactly from May through August. However, the wetter water years and drier water
 1797 years would generally continue having lower reservoir elevations through March, April, and into
 1798 May.



1799
 1800 **Figure 3-52. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 2**

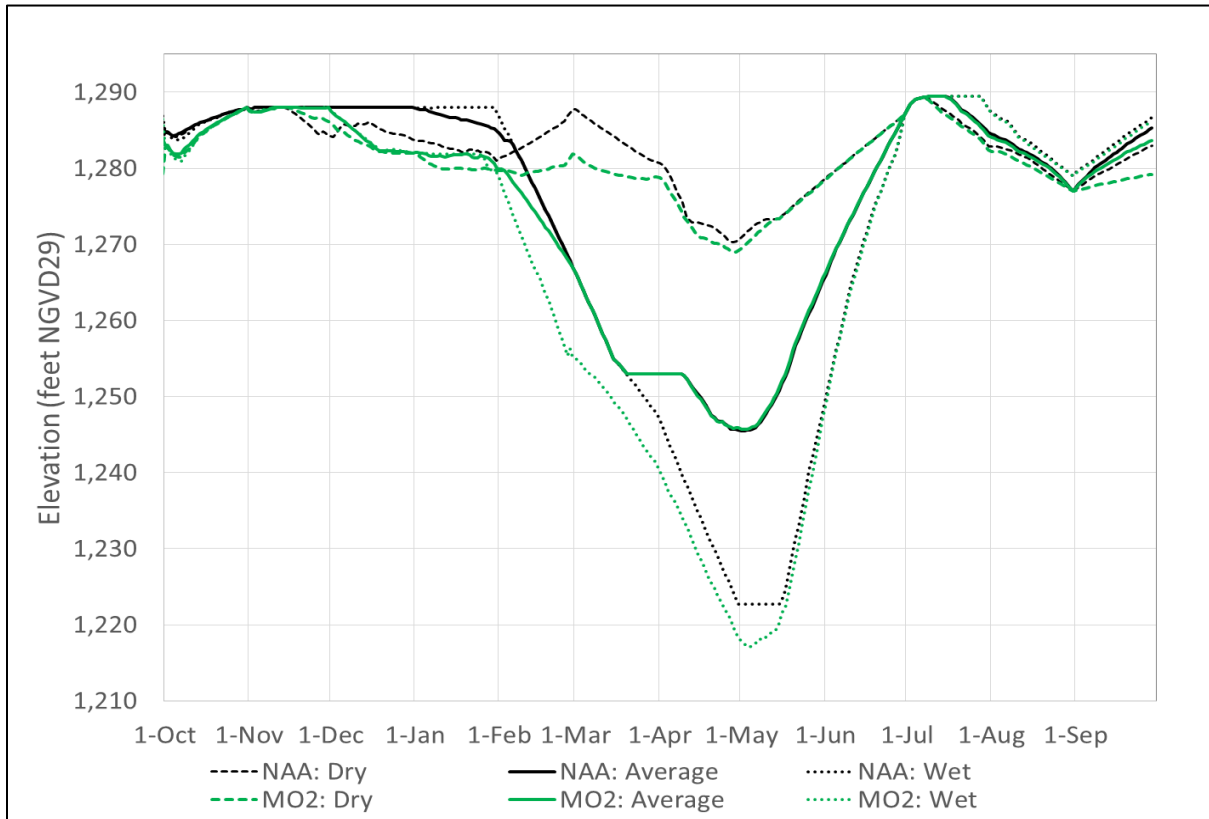
1801 Under MO2, the probability of drafting to very low reservoir elevations (elevation 1,222 feet
 1802 NGVD29 or below) at Lake Roosevelt on April 30 would increase when compared to the No
 1803 Action Alternative. This is due to an element in the *Update System FRM Calculation* measure
 1804 which calls for the FRM space requirement at Grand Coulee Dam to increase as the water
 1805 supply forecast increases. This is in contrast to the FRM space requirement at Grand Coulee
 1806 Dam for the No Action Alternative, which has a “flat spot” at elevation 1,222.7 feet NGVD29
 1807 where the FRM space requirement does not increase right away with the runoff forecast over a
 1808 certain range of runoff conditions.

1809 The effects of MO2 on the April 30 level of Lake Roosevelt are summarized as follows:

- 1810 • The chance of drawing the reservoir down to “empty” (elevation 1,208 feet NGVD29) on
- 1811 April 30 would be about 6 percent for MO2, as compared to about 5 percent for the No
- 1812 Action Alternative.
- 1813 • The chance of drawing the reservoir down to elevation 1,222 feet NGVD29 or below on
- 1814 April 30 would be about 15 percent for MO2, as compared to about 8 percent for the No
- 1815 Action Alternative.

1816 During the majority of the summer, reservoir elevations under MO2 would generally be the
 1817 same as those for the No Action Alternative. However, beginning in September and continuing
 1818 until the end of October, the reservoir would be lower under MO2 than the No Action
 1819 Alternative, primarily due to the *Slightly Deeper Draft for Hydropower* measure.

1820 Finally, Figure 3-53 shows median hydrographs for Lake Roosevelt in dry, average, and wet
 1821 years. Figure 3-53 provides another way to picture the effects described above, this time
 1822 categorized by water year type. In dry years, the level of Lake Roosevelt under MO2 would be
 1823 lower than for the No Action Alternative from mid-November through mid-May. In average
 1824 years it would be lower from December through February, and in wet years it would be lower
 1825 from December through mid-May. In all water year types, the September and October reservoir
 1826 elevations under MO2 would be lower than for the No Action Alternative.



1827 **Figure 3-53. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative**
 1828 **2**
 1829

1830 **Grand Coulee Dam Drum Gate Maintenance**

1831 Drum gate maintenance at Grand Coulee Dam is planned to occur annually during March, April,
1832 and May, but is not conducted in all years. The reservoir must be at or below elevation 1,255
1833 feet NGVD29 for 8 weeks to complete drum gate maintenance. Under MO2, the *Slightly Deeper*
1834 *Draft for Hydropower, Update System FRM Calculation, Planned Draft Rate at Grand Coulee,*
1835 and *Winter System FRM Space* measures would influence reservoir elevations during spring
1836 months.

1837 The changes in elevations for MO2 that influence the decision to conduct drum gate
1838 maintenance would not change significantly relative to the No Action Alternative (April 30 FRM
1839 elevation targets and drum gate initiation methodology is discussed in more detail in Part 1 of
1840 Appendix B). The decision to conduct drum gate maintenance is based on the February water
1841 supply forecast and the resulting April 30 FRM elevation projection (April 30 FRM elevation
1842 target at or below 1,255 or 1,265 feet NGVD29 depending on how recently the maintenance
1843 has been conducted). This is not to say the spring elevations are the same for the two
1844 alternatives, but rather that there are a similar number of years that elevations would allow for
1845 drum gate maintenance. In both MO2 and the No Action Alternative, drum gate maintenance
1846 would be achievable in 65 percent of the years.

1847 **Grand Coulee Dam Outflow**

1848 Under MO2, the *Slightly Deeper Draft for Hydropower, Update System FRM Calculation,*
1849 *Planned Draft Rate at Grand Coulee,* and *Winter System FRM Space* measures would directly
1850 affect outflows from Grand Coulee Dam. In addition, MO2 also has measures at Libby Dam
1851 (*Slightly Deeper Draft for Hydropower, Sliding Scale at Libby and Hungry Horse, Modified Draft*
1852 *at Libby,* and *December Libby Target Elevation*), and Hungry Horse Dam (*Slightly Deeper Draft*
1853 *for Hydropower and Sliding Scale at Libby and Hungry Horse*) which would affect inflows and
1854 outflows at Grand Coulee Dam. The outflows from Grand Coulee Dam would differ from the No
1855 Action Alternative depending on the time of year, as seen in the summary hydrograph in
1856 Figure 3-54.

1857 The change in average monthly outflow throughout the water year is presented in Table 3-24.

1858 Under MO2, changes in Grand Coulee outflow would come from several measures throughout
1859 the year. It is worth noting that MO2 does not have the water supply measures that are
1860 included in the other MOs (MO1, MO3, and MO4). Effects to outflow are described below, and
1861 where possible, the measure (or combination of measures) causing the effect is identified.

- 1862 • Under MO2, outflows in October would be lower than the No Action Alternative due to the
1863 change in end of September and end of October draft targets from the *Slightly Deeper Draft*
1864 *for Hydropower* measure. The median October value of the monthly average discharge
1865 would be 4.8 kcfs less than the No Action Alternative.
- 1866 • In November, the median value of the monthly average outflow would increase by 2.0 kcfs.
1867 This is primarily due to the *Slightly Deeper Draft for Hydropower* measure.

- 1868 • In December, the median value of the monthly average outflow would increase by 10.9 kcfs.
- 1869 This is primarily attributable to the measure for the *Winter System FRM Space* and *Slightly*
- 1870 *Deeper Draft for Hydropower* measures.
- 1871 • In January, February, and March, the median values of the monthly average outflow would
- 1872 decrease by 1.2, 3.0, and 5.2 kcfs, respectively due to the *Slightly Deeper Draft for*
- 1873 *Hydropower* and *Planned Draft Rate at Grand Coulee* measures.
- 1874 • In April, May, and June, the median values of the monthly average outflow would decrease
- 1875 by 2.5, 4.1, and 2.0 kcfs, respectively due mostly to changes in inflow, but in part to
- 1876 measures at Grand Coulee in April. However, the highest monthly average flows for June (at
- 1877 the 1 percent exceedance level) would increase by 3.6 kcfs.
- 1878 • Monthly average outflows in July and August would be 0.8 and 1.0 kcfs lower, respectively,
- 1879 than for the No Action Alternative due to changes in inflow.
- 1880 • In September, outflows would generally be greater than the No Action Alternative. The
- 1881 median value of the monthly average outflow would increase by 2.6 kcfs. This is primarily
- 1882 due to the change in the end of September target elevation from the *Slightly Deeper Draft*
- 1883 *for Hydropower* measure.
- 1884 • The *Grand Coulee Maintenance Operations* measure would not impact reservoir elevations
- 1885 or total outflows, but would reduce the hydraulic capacity through the power plants,
- 1886 resulting in additional spill and an increase in TDG in some situations.

1887 Finally, Figure 3-55 shows median hydrographs for Grand Coulee Dam outflow in dry, average,

1888 and wet years. MO2 and the No Action Alternative are shown. The figure provides another way

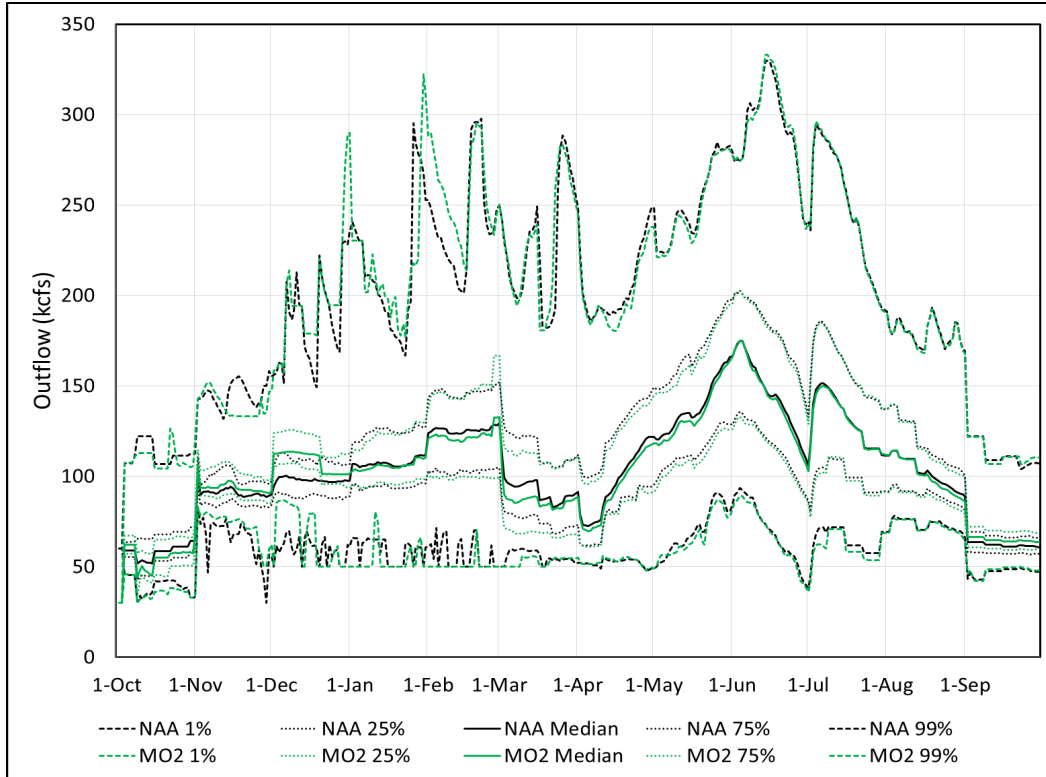
1889 to picture the effects described above, this time categorized by water year type.

1890 **Table 3-24. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 2**
1891 **(as change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	94	130	174	190	213	186	191	231	275	247	175	111
		25%	67	99	109	124	147	117	120	165	181	158	118	68
		50%	59	91	97	108	126	93	97	138	150	134	102	63
		75%	54	84	88	96	105	78	79	118	121	98	92	59
		99%	49	78	79	76	81	66	60	97	91	81	81	53
MO2	Change (kcfs)	1%	-3.3	1.7	5.8	1.2	17.9	-5.6	-7.6	-3.7	3.6	-0.3	-0.8	0.0
		25%	-5.0	3.7	8.7	-2.4	0.6	-3.5	-2.8	-4.5	-1.6	-0.4	-1.9	2.7
		50%	-4.8	2.0	10.9	-1.2	-3.0	-5.2	-2.5	-4.1	-2.0	-0.8	-1.0	2.6
		75%	-5.1	4.1	13.1	1.7	-3.5	-5.5	-1.8	-3.8	-2.5	-1.7	-1.9	2.3
		99%	-5.7	3.9	10.5	9.9	0.3	-3.8	-0.7	-5.2	-2.3	-1.8	-1.3	1.4
	Percent change	1%	-4%	1%	3%	1%	8%	-3%	-4%	-2%	1%	0%	0%	0%
		25%	-8%	4%	8%	-2%	0%	-3%	-2%	-3%	-1%	0%	-2%	4%
		50%	-8%	2%	11%	-1%	-2%	-6%	-3%	-3%	-1%	-1%	-1%	4%
		75%	-9%	5%	15%	2%	-3%	-7%	-2%	-3%	-2%	-2%	-2%	4%
		99%	-12%	5%	13%	13%	0%	-6%	-1%	-5%	-2%	-2%	-2%	3%

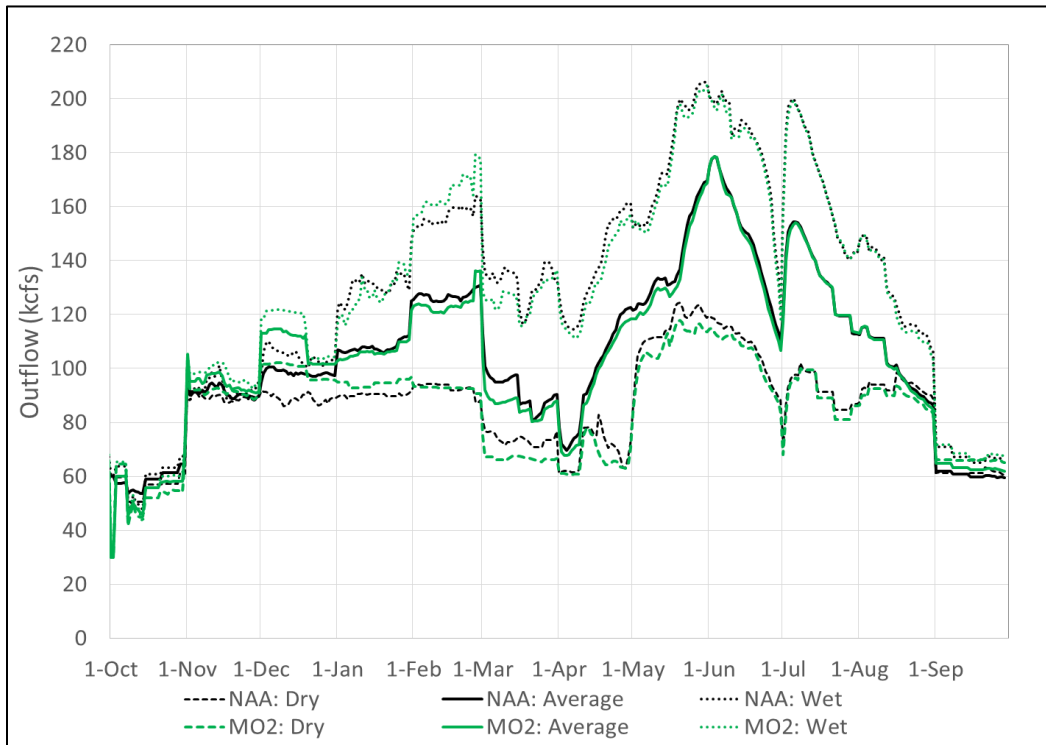
1892 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No

1893 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.



1894
 1895
 1896

Figure 3-54. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective Alternative 2



1897
 1898
 1899

Figure 3-55. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2

1900 **Middle Columbia River below Grand Coulee Dam**

1901 Under MO2, the pattern of flow changes in the middle Columbia River would be similar to those
1902 described for Grand Coulee Dam outflow, with the changes occurring for the same reasons as
1903 described for Grand Coulee Dam outflow. The reservoir elevation at Chief Joseph Dam would
1904 not change from the No Action Alternative.

1905 Table 3-25 shows changes in the median values of monthly average flows at locations in the
1906 middle Columbia River.

1907 **Table 3-25. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative**
1908 **2 (as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcf/s)	Lake Roosevelt Inflow	64	82	92	95	100	65	69	131	166	133	98	75
	Grand Coulee	59	91	97	108	126	93	97	138	150	134	102	63
	Chief Joseph	58	91	96	108	127	94	98	139	150	135	103	63
	Wells	59	93	98	110	129	95	101	150	163	141	105	65
	Priest Rapids	60	96	102	115	133	100	108	162	178	147	108	68
Change (kcf/s)	Lake Roosevelt Inflow	-0.2	4.8	4.3	-0.4	-0.4	-0.5	-1.4	-3.3	-1.4	-0.8	-0.4	-0.4
	Grand Coulee	-4.8	2.0	10.9	-1.2	-3.0	-5.2	-2.5	-4.1	-2.0	-0.8	-1.0	2.6
	Chief Joseph	-4.1	2.2	10.8	-0.5	-2.9	-5.2	-2.5	-4.0	-2.0	-1.1	-0.9	2.6
	Wells	-2.8	1.9	10.7	-0.4	-2.7	-5.2	-2.2	-4.3	-2.1	-1.2	-0.7	2.3
	Priest Rapids	-2.5	2.7	11.3	-0.5	-2.9	-5.1	-2.4	-4.5	-2.0	-0.6	-0.5	2.1
Percent Change	Lake Roosevelt Inflow	0%	6%	5%	0%	0%	-1%	-2%	-3%	-1%	-1%	0%	0%
	Grand Coulee	-8%	2%	11%	-1%	-2%	-6%	-3%	-3%	-1%	-1%	-1%	4%
	Chief Joseph	-7%	2%	11%	-1%	-2%	-6%	-3%	-3%	-1%	-1%	-1%	4%
	Wells	-5%	2%	11%	0%	-2%	-5%	-2%	-3%	-1%	-1%	-1%	3%
	Priest Rapids	-4%	3%	11%	0%	-2%	-5%	-2%	-3%	-1%	0%	-1%	3%

1909 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
1910 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.

1911 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
1912 **HARBOR DAMS**

1913 **Dworshak Dam**

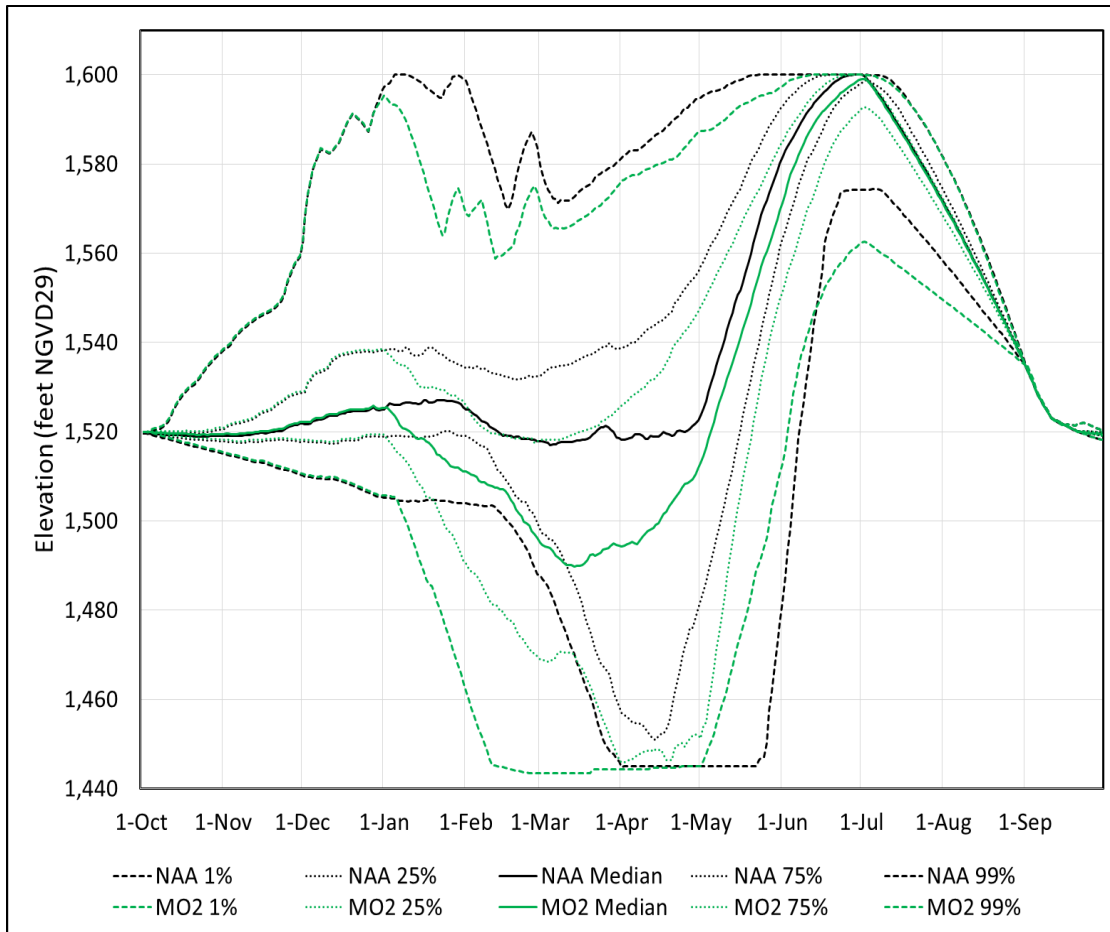
1914 Under MO2, the *Slightly Deeper Draft for Hydropower* measure would have a direct effect on
1915 Dworshak Dam operations. Reservoir water levels would differ from the No Action Alternative,
1916 as shown in the summary hydrograph, Figure 3-56.

1917 In MO2, the *Slightly Deeper Draft for Hydropower* measure would allow for additional
1918 hydropower generation and hydropower flexibility by drafting to reservoir elevations lower
1919 than required for FRM purposes. This measure would affect reservoir levels beginning in

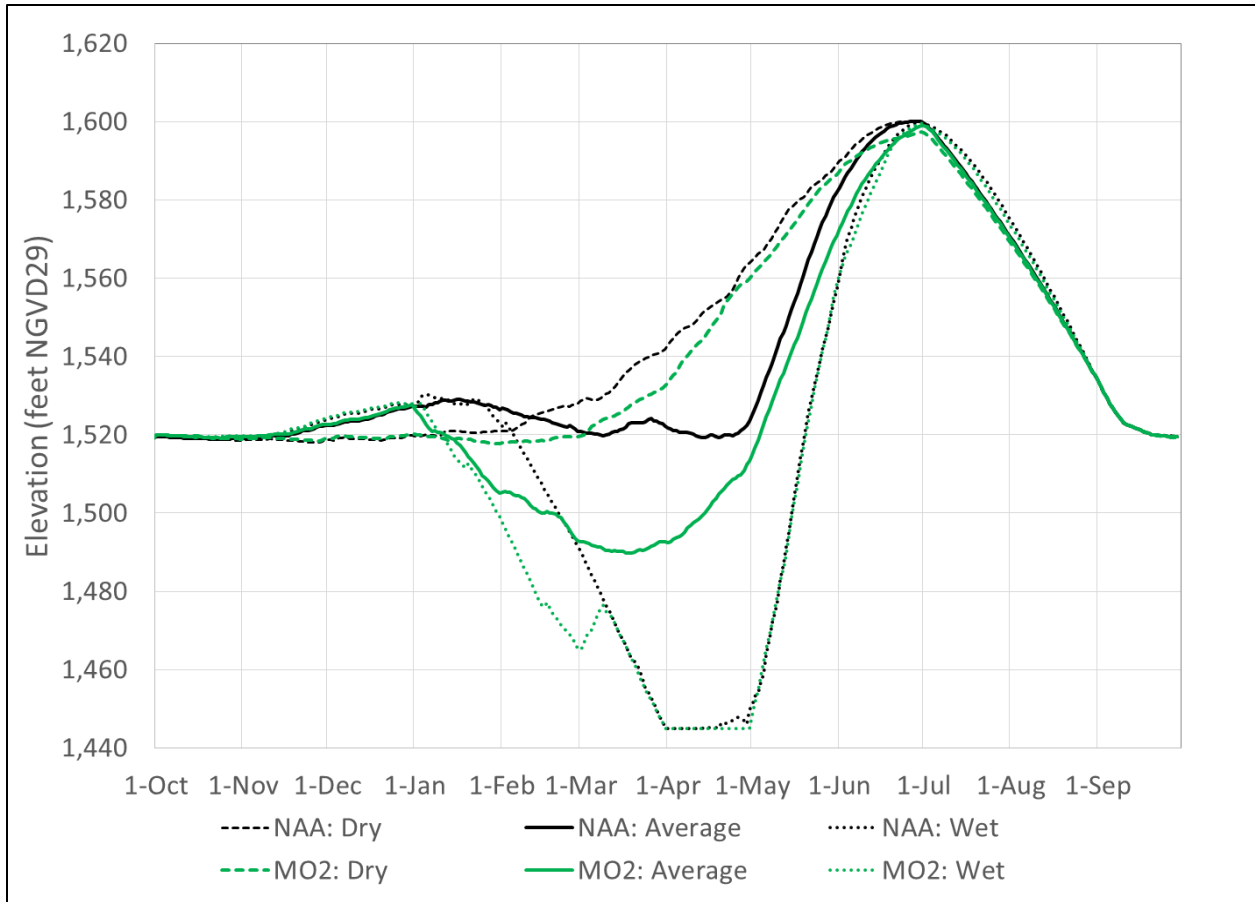
1920 January of each year, with elevations consistently lower than the No Action Alternative through
 1921 June.

1922 Under the No Action Alternative, Dworshak Reservoir refills to within 0.5 foot of the normal full
 1923 reservoir elevation of 1,600 feet NGVD29 in about 80 percent of years. Under MO2, ResSim
 1924 modeling assumptions did not represent the intended operations and instead showed the
 1925 reservoir would have a decreased refill probability, refilling to within 0.5 foot of the normal full
 1926 reservoir elevation in about 48 percent of years. It is likely that in real-time operations, the refill
 1927 probability for Dworshak Reservoir under MO2 would be higher than shown in modeled results
 1928 and more closely aligned with the No Action Alternative. Integrating the *Slightly Deeper Draft*
 1929 *for Hydropower* measure at Dworshak Reservoir with model refill logic yielded lower peak
 1930 reservoir elevations than for the No Action Alternative. MO2 does not delay the start of
 1931 summer draft until July 7 like the No Action Alternative does, which also contributes to the
 1932 reduced peak reservoir elevations in MO2.

1933 Another way to picture how Dworshak Reservoir levels under MO2 would differ from the No
 1934 Action Alternative is shown in median hydrographs for dry, average, and wet years
 1935 (Figure 3-57). The most notable differences in Figure 3-57 are seen in January through June.



1936
 1937 **Figure 3-56. Dworshak Reservoir Summary Hydrograph for Multiple Objective Alternative 2**



1938
1939
1940

Figure 3-57. Dworshak Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 2

1941 **Dworshak Dam Outflow**

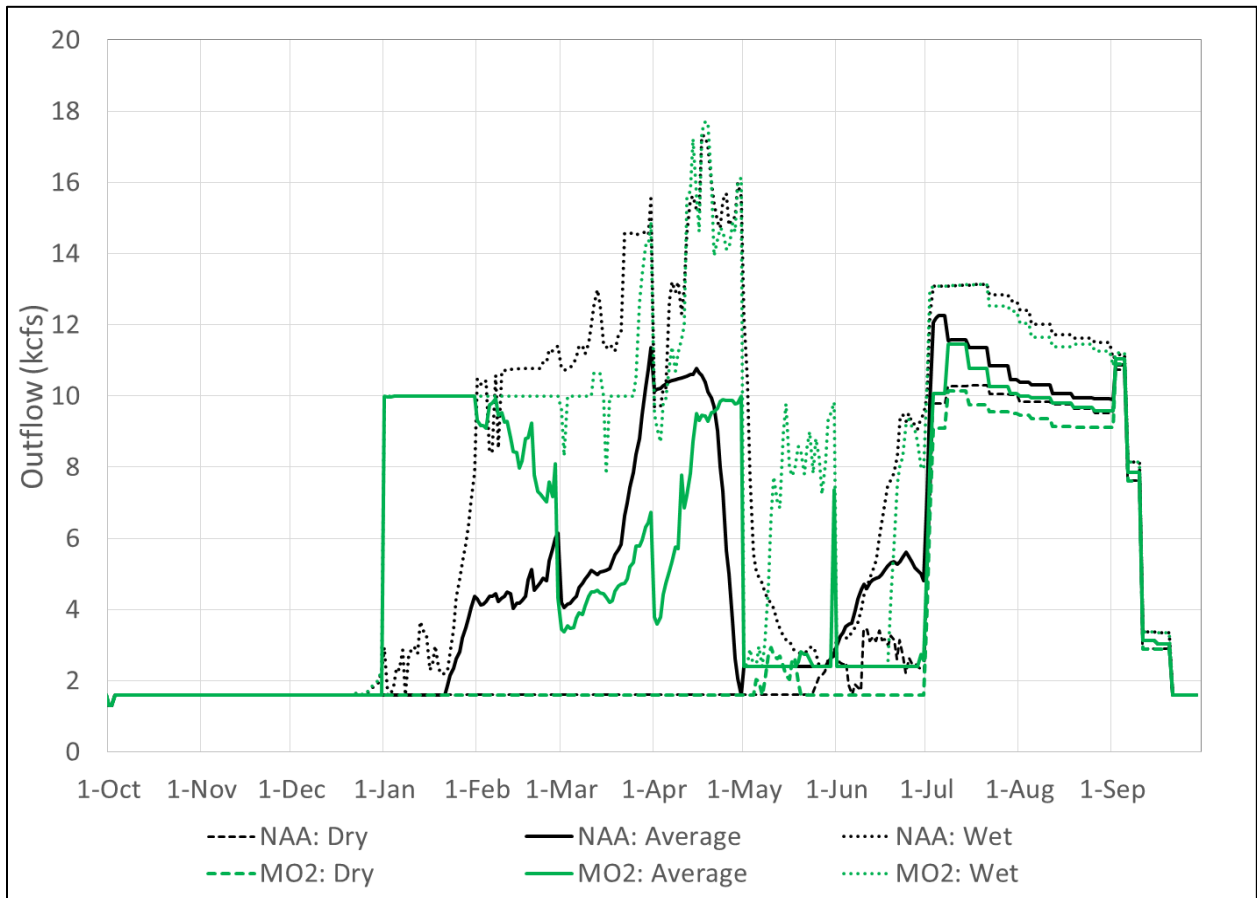
1942 Under MO2, the *Slightly Deeper Draft for Hydropower* measure would have a direct effect on
1943 Dworshak Dam outflows. The *Ramping Rates for Safety* measure, calling for less restrictive
1944 ramping rates, could result in greater hourly or daily outflow changes at Dworshak Dam as well as
1945 the other CRS dams. The outflows would differ from the No Action Alternative from January
1946 through August. Figure 3-58 shows median hydrographs for Dworshak Dam outflow in dry,
1947 average, and wet years.

1948 The change in average monthly outflow is characterized in Table 3-26.

1949 The months of January through August would all have changes in outflow as compared to the
1950 No Action Alternative. The changes in outflow are attributable to the *Slightly Deeper Draft for*
1951 *Hydropower* measure. Due to the deeper than intended drafting in ResSim in the spring, the
1952 intended flows would likely be lower in the spring and higher in the summer than the modeled
1953 values.

- 1954 • In January, outflows would increase. The median value of the monthly average outflow
1955 would increase by 6.6 kcfs.

- 1956 • In February, outflows would increase for all but the highest flows. The median value of the
 1957 monthly average outflow would increase by 2.0 kcfs.
- 1958 • In March, outflows would decrease. The median value of the monthly average outflow
 1959 would decrease by 1.5 kcfs.
- 1960 • The outflow in April would decrease. The median value of the monthly average outflow
 1961 would decrease by 1.9 kcfs.
- 1962 • In May, outflows would increase for all but the highest flows. The median value of the
 1963 monthly average outflow would increase by 1.0 kcfs.
- 1964 • In June, outflows would decrease for all but the highest flows. The median value of the
 1965 monthly average outflow would decrease by 2.2 kcfs.
- 1966 • In July, outflows would decrease. The median value of the monthly average outflow would
 1967 decrease by 0.2 kcfs.
- 1968 • In August, the median value of the monthly average outflow would decrease by 0.4 kcfs.
 1969 The lowest outflows (at the 99 percent exceedance level) would decrease by 3.2 kcfs.



1970
 1971 **Figure 3-58. Dworshak Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 1972 **Alternative 2**

1973 **Table 3-26. Dworshak Dam Monthly Average Outflow for Multiple Objective Alternative 2 (as**
1974 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	1.7	1.6	8.7	13.5	23.3	25.0	25.0	17.3	15.6	13.2	13.6	6.4
		25%	1.6	1.6	1.9	4.2	9.3	11.8	13.2	6.2	7.5	11.9	11.0	5.2
		50%	1.6	1.6	1.6	2.1	5.1	6.2	9.6	3.5	4.8	10.7	10.2	5.0
		75%	1.6	1.6	1.6	1.6	1.6	2.3	4.6	2.4	2.4	9.6	9.8	4.8
		99%	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	7.4	9.3
MO2	Change (kcfs)	1%	0.0	0.0	0.0	7.4	-4.2	0.0	-0.6	-5.5	1.2	0.0	0.0	-0.1
		25%	0.0	0.0	0.0	5.5	0.7	-2.6	-0.3	0.5	-2.6	-0.2	-0.4	0.0
		50%	0.0	0.0	0.0	6.6	2.0	-1.5	-1.9	1.0	-2.2	-0.2	-0.4	0.0
		75%	0.0	0.0	0.0	2.3	0.3	-0.7	-2.5	0.6	-0.1	-0.3	-0.7	0.0
		99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-3.2	-0.1
	Percent change	1%	0%	0%	0%	55%	-18%	0%	-2%	-31%	8%	0%	0%	-1%
		25%	0%	0%	0%	129%	7%	-22%	-2%	8%	-35%	-1%	-4%	-1%
		50%	0%	0%	0%	311%	39%	-24%	-20%	27%	-45%	-2%	-4%	0%
		75%	0%	0%	0%	141%	19%	-30%	-54%	25%	-3%	-4%	-7%	-1%
		99%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%	-34%	-1%

1975 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
1976 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.

1977 **Lower Snake River Reservoir Elevations**

1978 Under MO2, the reservoir elevations at the four lower Snake River dams would differ from
1979 those of the No Action Alternative due to the *Full Range Reservoir Operations* measure, which
1980 calls for operating within the full reservoir operating range throughout the year, instead of
1981 reducing the normal operating range in the MOP season, April through August. The normal
1982 operating ranges for each of the four projects are described below, along with a description of
1983 the change from No Action Alternative:

- 1984 • Lower Granite Dam would use the normal operating range of 733.0 to 738.0 feet NGVD29
1985 year-round. This is a 4.0-foot elevation range increase and a 4.0-foot increase in the upper
1986 elevation from April through August compared to the No Action Alternative.
- 1987 • Little Goose Dam would use the normal operating range of 633.0 to 638.0 feet NGVD29
1988 year round. This is a 4.0-foot elevation range increase and a 4.0-foot increase in the upper
1989 elevation from April through August compared to the No Action Alternative.
- 1990 • Lower Monumental Dam would use the normal operating range of 537.0 to 540.0 feet
1991 NGVD29 year round. This is a 2.0-foot elevation range increase and a 2.0-foot increase in
1992 the upper elevation from April through August compared to the No Action Alternative.
- 1993 • Ice Harbor Dam would use the normal operating range of 437.0 to 440.0 feet NGVD29 year
1994 round. This is a 2.0-foot elevation range increase and a 2.0-foot increase in the upper
1995 elevation from April through August compared to the No Action Alternative.

1996 **Clearwater River below Dworshak Dam and the Lower Snake River**

1997 Under MO2, the pattern of outflow changes from Dworshak Dam from January through August
1998 would continue downstream. While the percent changes in flow from the No Action Alternative
1999 would be pronounced in the Clearwater River system, they would become diluted as the
2000 Clearwater River merges with the Snake River near Lewiston, Idaho. This is seen in Table 3-27,
2001 which shows changes in median values of monthly average flows. All changes are attributable
2002 to the *Slightly Deeper Draft for Hydropower* measure in MO2.

2003 **Table 3-27. Lower Snake Basin Monthly Average Flows for Multiple Objective Alternative 2**
2004 **(as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcf/s)	Dworshak	1.6	1.6	1.6	2.1	5.1	6.2	9.6	3.5	4.8	10.7	10.2	5.0
	Spalding, ID	3.4	4.5	4.7	5.9	10.6	15.5	26.8	33.4	28.7	17.0	12.2	6.5
	Snake+Clearwater	19.7	20.9	23.9	28.3	39.0	47.2	69.7	94.4	96.4	47.9	29.2	22.6
	Lower Granite	19.8	21.0	23.7	28.4	39.3	48.0	71.8	95.6	97.4	48.6	29.1	22.5
	Ice Harbor	20.2	21.4	24.5	29.4	42.0	50.7	73.0	95.4	97.2	48.4	28.1	21.2
Change (kcf/s)	Dworshak	0.0	0.0	0.0	6.6	2.0	-1.5	-1.9	1.0	-2.2	-0.2	-0.4	0.0
	Spalding, ID	0.0	0.0	0.0	6.3	2.6	-2.0	-1.7	0.6	-1.7	-0.2	-0.5	0.0
	Snake+Clearwater	1.0	0.0	0.0	5.8	1.9	-1.6	-0.8	0.4	-2.3	-0.1	-1.0	-0.1
	Lower Granite	0.4	0.0	0.0	5.4	1.7	-1.6	-1.4	0.2	-1.9	-0.7	-1.0	0.0
	Ice Harbor	0.4	0.0	0.0	5.2	2.0	-1.6	-1.3	0.4	-2.0	-0.8	-0.7	-0.1
Percent Change	Dworshak	0%	0%	0%	311%	39%	-24%	-20%	27%	-45%	-2%	-4%	0%
	Spalding, ID	0%	0%	0%	107%	24%	-13%	-6%	2%	-6%	-1%	-4%	0%
	Snake+Clearwater	5%	0%	0%	20%	5%	-3%	-1%	0%	-2%	0%	-3%	0%
	Lower Granite	2%	0%	0%	19%	4%	-3%	-2%	0%	-2%	-2%	-3%	0%
	Ice Harbor	2%	0%	0%	18%	5%	-3%	-2%	0%	-2%	-2%	-2%	0%

2005 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
2006 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.

2007 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

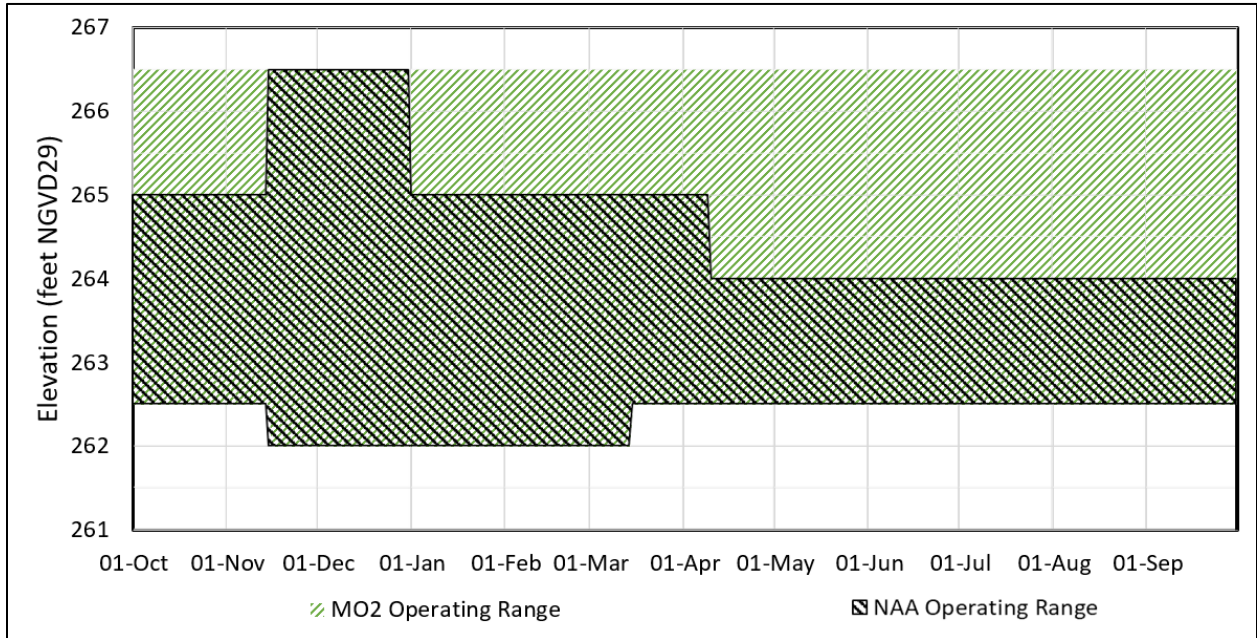
2008 **Lower Columbia River Reservoir Elevations**

2009 Under MO2, there would be no changes to the reservoir elevations at McNary Dam, The Dalles
2010 Dam, or Bonneville Dam. At John Day Dam, the *John Day Full Pool* measure calls for operating
2011 the reservoir in a range that goes up to 266.5 feet NGVD29 year round, except as needed for
2012 FRM. When operation is needed for FRM, the full operating range (257.0 to 268.0 feet NGVD29)
2013 may be used, as is the case for the No Action Alternative. The operating elevation range
2014 changes as compared to No Action Alternative are described below:

- 2015 • January 1 to March 14: Compared to the No Action Alternative (262.0 and 265.0 feet
2016 NGVD29), the overall range and maximum elevation is increased by 1.5 feet.
- 2017 • March 15 to April 9 and October 1 to November 14: Compared to the No Action Alternative
2018 (262.5 and 265.0 feet NGVD29), the overall range and maximum elevation is increased by
2019 1.5 feet.

2020 • April 10 to September 30: Compared to the No Action Alternative (262.5 and 264.0 feet
2021 NGVD29), the overall range and maximum elevation is increased by 2.5 feet.

2022 The operating range for John Day Dam for Multi Objective Alternative 2 is shown in Figure 3-59.
2023 The No Action Alternative operating range is shown for comparison purposes.



2024
2025 **Figure 3-59. John Day Dam Operating Range for Multiple Objective Alternative 2**

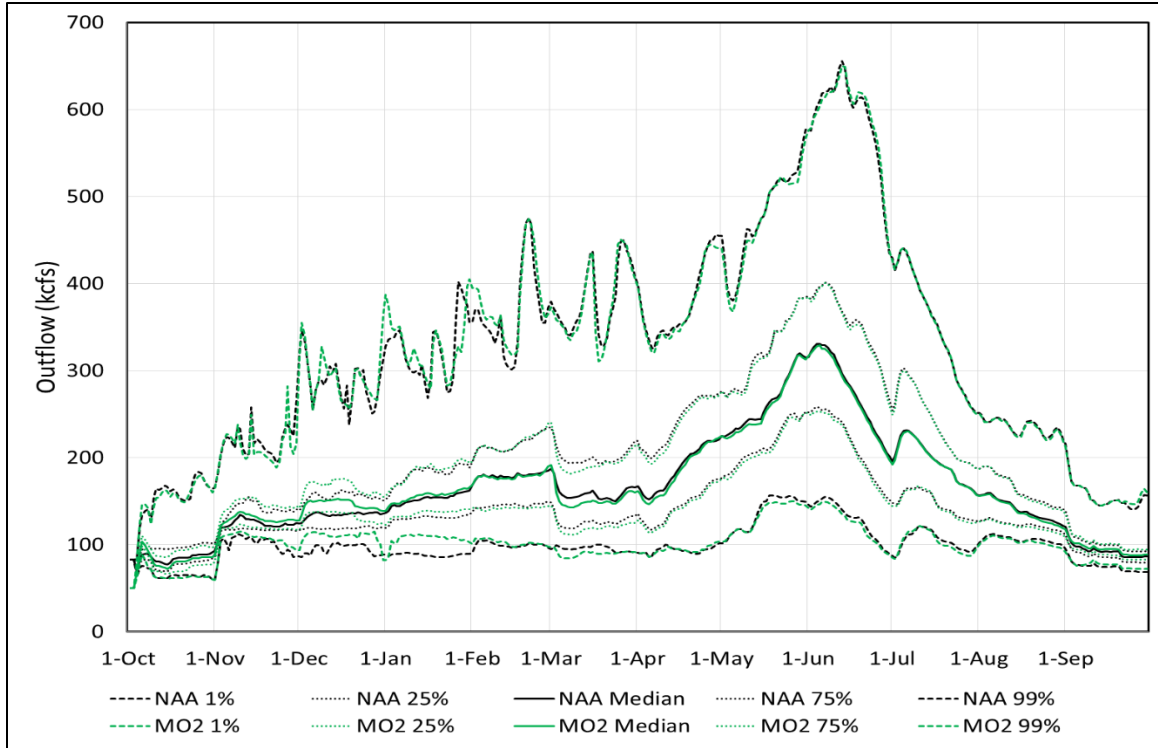
2026 Note: John Day may be operated between 257 feet and 268 feet NGVD29 for FRM purposes. These limits are not
2027 shown on this figure in order to show greater detail in the vertical scale.

2028 **Lower Columbia River Flows**

2029 Under MO2, the *Slightly Deeper Draft for Hydropower, Sliding Scale at Libby and Hungry Horse,*
2030 *Modified Draft at Libby, December Libby Target Elevation, Update System FRM Calculation,*
2031 *Planned Draft Rate at Grand Coulee, Winter System FRM Space* measures would cause changes
2032 in flow patterns in the lower Columbia River.

2033 At McNary Dam, the outflows under MO2 would differ from the No Action Alternative to
2034 various extents through the water year. The magnitude and timing of differences in flow are
2035 displayed in the summary hydrograph, Figure 3-60.

2036 In addition to the daily outflow values depicted in Figure 3-60, the monthly average outflows
2037 from McNary Dam that would occur under MO2 were compared to those for the No Action
2038 Alternative, as shown in Table 3-28.



2039
 2040 **Figure 3-60. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 2**

2041 Conclusions from this comparison are below:

- 2042 • In November, the median value of the monthly average outflow would increase by 4.1 kcfs.
 2043 A combination of measures would cause this, with the *Slightly Deeper Draft for Hydropower*
 2044 measure being the main reason for the flow increases.
- 2045 • In December and January, the median value of the monthly average outflow would increase
 2046 by 10.8 and 4.7 kcfs, respectively. A combination of measures would cause these flow
 2047 increases, with *Slightly Deeper Draft for Hydropower* and *Winter System FRM Space* being
 2048 the measures primarily responsible for the change.
- 2049 • In March through June, the median value of the monthly average outflow would decrease
 2050 by 6.4, 4.7, 3.6, and 3.2 kcfs, respectively. A combination of measures would cause this,
 2051 with the *Slightly Deeper Draft for Hydropower* measure, which shifts some system flows
 2052 from the spring months into the winter months, being one of them.
- 2053 • In September, the median value of the monthly average outflow would increase by 2.7 kcfs.
 2054 In October, it would decrease by 3.9 kcfs. These changes are due to the *Slightly Deeper*
 2055 *Draft for Hydropower* measure changing the end of September draft target at Grand Coulee
 2056 Dam.

2057 Finally, median hydrographs for McNary Dam outflow in dry, average, and wet years are shown
 2058 in Figure 3-61. The figure provides another way to picture the effects described above, this time
 2059 categorized by water year type. Higher outflows would occur in November and December for

2060 all water year types. In January, the dry and average years would continue to have higher
2061 outflows. In March outflows would decrease for all water year types.

2062 The effects on McNary Dam outflow from MO2 would occur similarly, and for the same
2063 reasons, at John Day Dam, The Dalles Dam, and Bonneville Dam. Along the lower Columbia
2064 River, the median value of the average monthly flow for MO2 would be higher than the No
2065 Action Alternative in some months (for example, November through January), and lower in
2066 others (for example, March through June). The flow change patterns seen at the confluence of
2067 the Columbia and Snake Rivers continue downstream to other locations as can be seen in
2068 Table 3-29.

2069 **Table 3-28. McNary Dam Monthly Average Outflow for Multiple Objective Alternative 2 (as**
2070 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	141	187	279	280	327	329	346	451	562	342	231	152
		25%	95	143	155	181	216	200	236	313	352	243	163	100
		50%	85	124	136	154	182	159	192	260	285	198	141	93
		75%	79	116	118	133	147	130	147	231	217	147	124	87
		99%	73	112	109	108	115	107	106	178	160	122	114	81
MO2	Change (kcfs)	1%	-4.2	1.1	4.5	9.6	4.3	-5.1	-4.4	-4.7	2.1	-1.0	-0.8	0.0
		25%	-4.0	3.1	10.6	1.6	1.2	-6.1	-4.4	-1.7	-3.7	-1.7	-2.4	1.5
		50%	-3.9	4.1	10.8	4.7	0.3	-6.4	-4.7	-3.6	-3.2	-0.5	-1.7	2.7
		75%	-4.5	1.7	16.0	7.1	-2.7	-6.1	-3.6	-2.6	-4.5	-0.8	-1.9	2.7
		99%	-4.3	0.1	8.4	9.6	0.9	-2.9	0.4	-6.8	-2.5	-1.7	-2.9	3.0
	Percent change	1%	-3%	1%	2%	3%	1%	-2%	-1%	-1%	0%	0%	0%	0%
		25%	-4%	2%	7%	1%	1%	-3%	-2%	-1%	-1%	-1%	-1%	1%
		50%	-5%	3%	8%	3%	0%	-4%	-2%	-1%	-1%	0%	-1%	3%
		75%	-6%	1%	14%	5%	-2%	-5%	-2%	-1%	-2%	-1%	-2%	3%
		99%	-6%	0%	8%	9%	1%	-3%	0%	-4%	-2%	-1%	-3%	4%

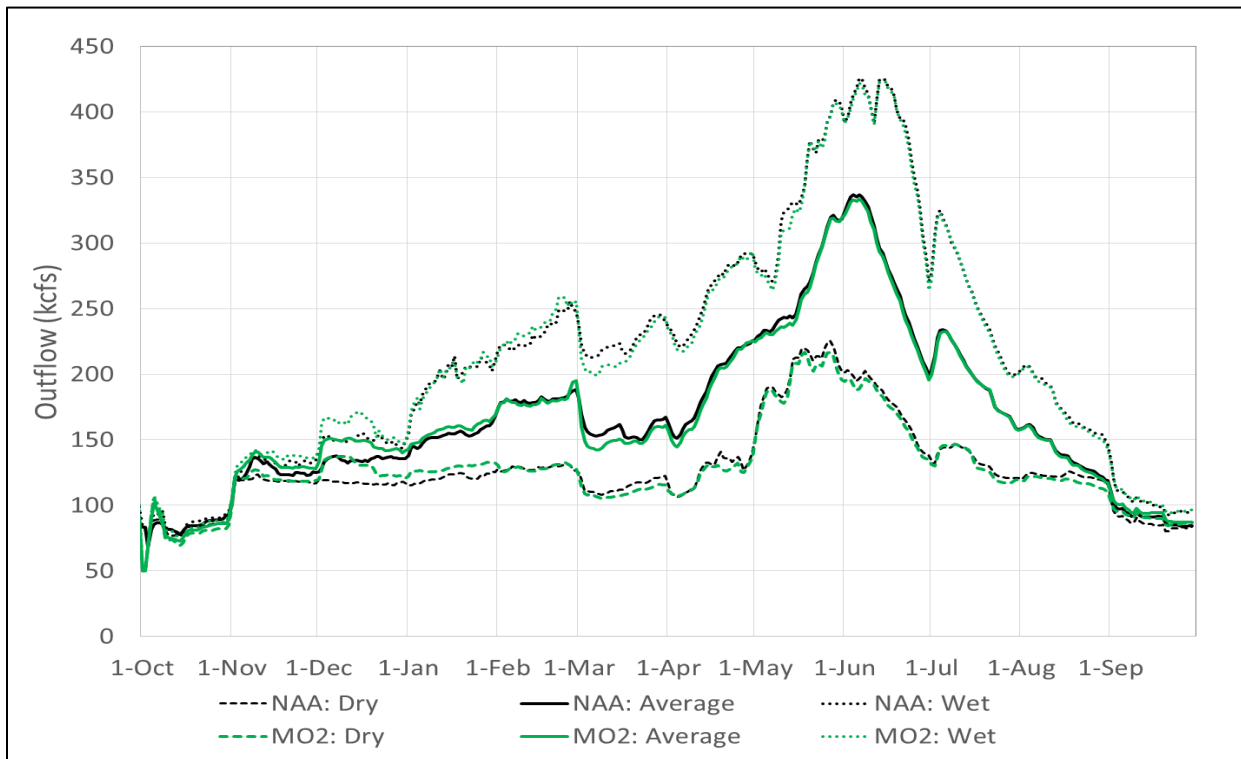
2071 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
2072 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.

2073 **Table 3-29. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 2**
2074 **(as change from No Action Alternative)**

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcfs)	Columbia+ Snake	83	122	134	151	181	157	188	260	288	199	140	91
	McNary	85	124	136	154	182	159	192	260	285	198	141	93
	John Day	85	125	140	156	185	165	198	267	288	197	141	93
	The Dalles	90	130	146	163	192	172	206	273	293	202	146	97
	Bonneville	91	135	152	170	199	179	213	275	296	204	149	99
	Columbia + Willamette	108	178	225	252	267	233	260	314	319	216	159	111
	Columbia + Cowlitz	115	196	257	282	295	255	283	334	336	226	165	117

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Change (kcfs)	Columbia + Snake	-2.5	4.0	9.9	3.7	0.1	-6.2	-4.3	-3.8	-3.6	-0.9	-1.5	2.6
	McNary	-3.9	4.1	10.8	4.7	0.3	-6.4	-4.7	-3.6	-3.2	-0.5	-1.7	2.7
	John Day	-4.1	3.9	10.8	4.0	0.2	-6.2	-4.0	-3.3	-3.7	-0.7	-1.7	2.8
	The Dalles	-4.7	3.7	10.4	3.9	-0.3	-6.0	-3.6	-3.5	-3.5	-0.6	-2.0	2.8
	Bonneville	-2.8	3.8	10.7	3.3	0.3	-6.4	-4.1	-3.9	-3.1	-0.6	-2.4	2.4
	Columbia + Willamette	-3.3	3.5	11.5	4.9	0.1	-5.3	-4.4	-3.7	-3.2	-0.6	-2.8	2.3
	Columiba + Cowlitz	-3.0	3.6	13.4	4.1	-1.1	-5.5	-4.1	-3.2	-3.4	-0.6	-2.4	1.9
Percent Change	Columbia+ Snake	-3%	3%	7%	2%	0%	-4%	-2%	-1%	-1%	0%	-1%	3%
	McNary	-5%	3%	8%	3%	0%	-4%	-2%	-1%	-1%	0%	-1%	3%
	John Day	-5%	3%	8%	3%	0%	-4%	-2%	-1%	-1%	0%	-1%	3%
	The Dalles	-5%	3%	7%	2%	0%	-4%	-2%	-1%	-1%	0%	-1%	3%
	Bonneville	-3%	3%	7%	2%	0%	-4%	-2%	-1%	-1%	0%	-2%	2%
	Columbia + Willamette	-3%	2%	5%	2%	0%	-2%	-2%	-1%	-1%	0%	-2%	2%
	Columiba + Cowlitz	-3%	2%	5%	1%	0%	-2%	-1%	-1%	-1%	0%	-1%	2%

2075 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO2 flows lower than the No
2076 Action Alternative flows; green shading denotes MO2 flows higher than the No Action Alternative flows.



2077
2078 **Figure 3-61. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective**
2079 **Alternative 2**

2080 **SUMMARY OF EFFECTS**

2081 Under MO2, the largest changes in water levels occur at Libby, Hungry Horse, Grand Coulee,
2082 and Dworshak Dams. Lake Kocanusa water levels are substantially lower in most years from
2083 November through June, but can be higher in the drawdown period starting in January in larger
2084 forecast years, and reservoir levels are slightly higher in the later summer months. Water levels

2085 in Hungry Horse Reservoir are lower from January through June in most years, and lower pool
2086 levels in the rest of the year are less common. Lake Roosevelt water levels are lower in
2087 December through March and at the end of September. Dworshak Reservoir is drawn deeper in
2088 January, and it stays lower through July due to impacts to refill by assumptions not representing
2089 the intended operation.

2090 The largest impacts to river flow occur immediately below Libby, Hungry Horse, Grand Coulee,
2091 and Dworshak Dams, and total flow changes are largest below Grand Coulee Dam. Changes in
2092 Libby outflow vary greatly across the year; November and December releases are much higher,
2093 otherwise flows are lower, particularly in January and May. Hungry Horse outflow is notably
2094 higher in January and February most years, and lower the rest of the year, particularly in May
2095 and June. These flow changes carry through the Flathead and Pend Oreille River Basins
2096 downstream. Flow in the Columbia River below Grand Coulee is higher in November and
2097 December, lower in the spring, and then slightly higher in September followed by lower
2098 October flows. Dworshak outflow is higher in January and February and lower March through
2099 June. With the exception of December, which can be more than 10 percent higher in lower
2100 water years, changes in average monthly flow through the lower Columbia River are within 5
2101 percent of No Action Alternative for all months for most years.

2102 **3.2.4.6 Multiple Objective Alternative 3**

2103 As the effects of MO3 are presented, they will be displayed along with the No Action
2104 Alternative to illuminate the timing and magnitude of differences in water conditions between
2105 it and the No Action Alternative. Similar to previous sections, the operational measure (or
2106 measures) from MO3 which would result in changes from the No Action Alternative, are
2107 identified to the extent possible.

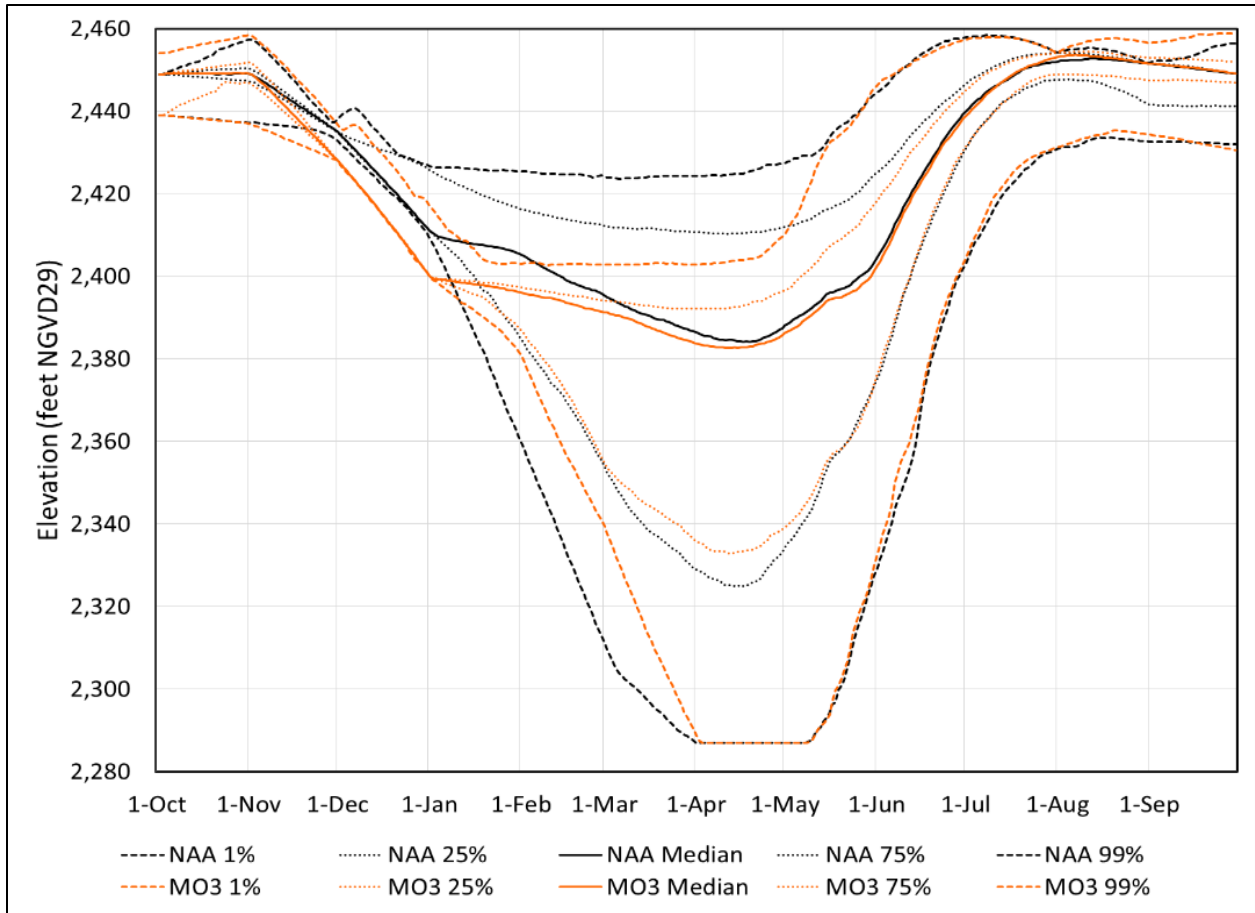
2108 It should be noted that the *Ramping Rates for Safety* measure in MO3 would allow for less
2109 restrictive ramping rates at all CRS projects, meaning that changes in outflow could be greater
2110 in magnitude than for the No Action Alternative. This measure was implemented to the extent
2111 possible in the hydroregulation modeling (ramping rates restrictions at Libby and Hungry Horse
2112 Dams were relaxed, approximated by doubling the restrictions) but it is not reflected in
2113 modeling at the other CRS projects. Effects on power generation and transmission are discussed
2114 in Section 3.7 of this EIS.

2115 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

2116 **Lake Kooconusa (Libby Dam Reservoir) Elevation**

2117 Under MO3, the *Ramping Rates for Safety*, *Sliding Scale at Libby and Hungry Horse*, *Modified*
2118 *Draft at Libby*, and *December Libby Target Elevation* measures would have a direct effect on
2119 Libby Dam operations.

2120 Reservoir water levels in Lake Kooconusa would differ from the No Action Alternative, as shown
2121 in the summary hydrograph, Figure 3-62.



2122
 2123 **Figure 3-62. Lake Kocanusa Summary Hydrograph for Multiple Objective Alternative 3**

2124 MO3 would generally have the same end-of-October reservoir elevation as the No Action
 2125 Alternative. However, over the course of November and December the reservoir elevations for
 2126 MO3 would be lower than for the No Action Alternative due to the *December Libby Target*
 2127 *Elevation* measure, resulting in an end-of-December elevation of 2,400 feet NGVD29 in most
 2128 years.

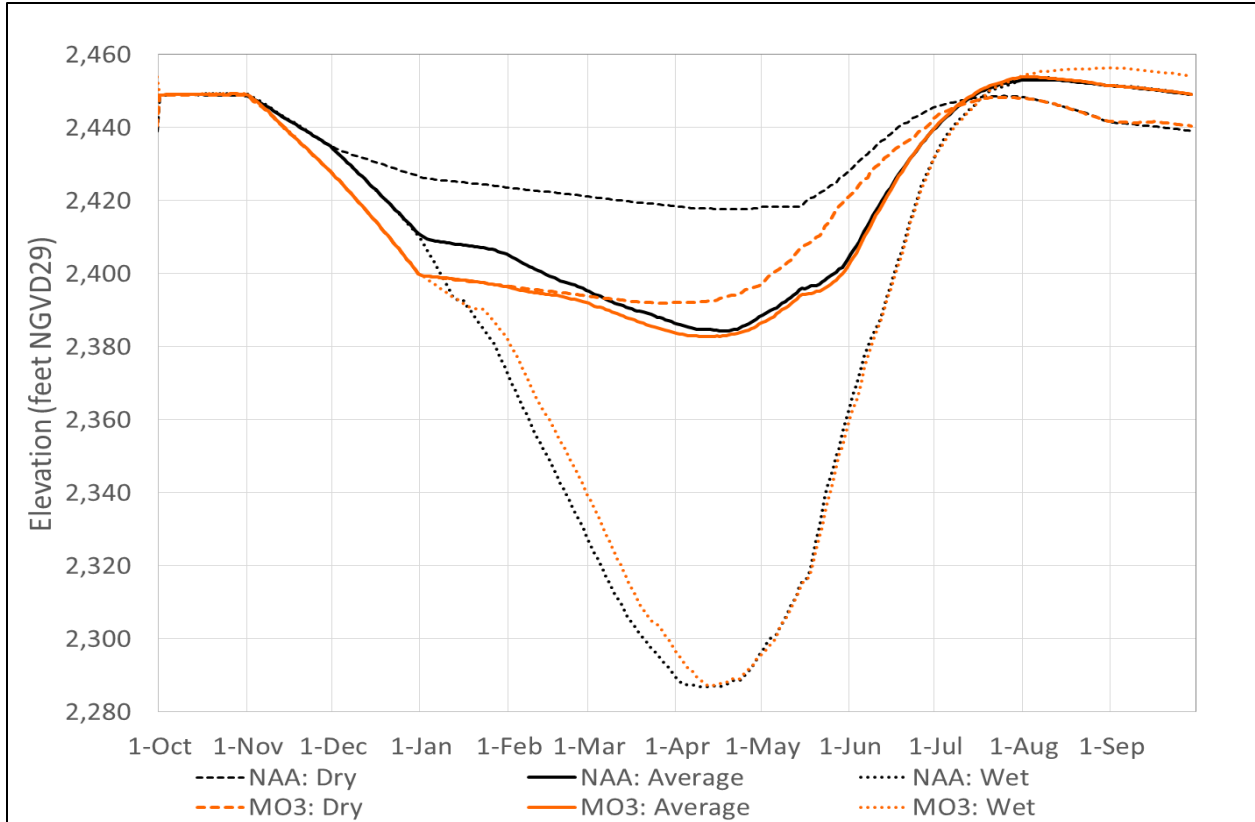
2129 Through the remaining winter months and into the early spring, reservoir levels would
 2130 generally continue to be lower under MO3 than they would be for the No Action Alternative,
 2131 though this is not always the case as seen in the 99 percent exceedance and 75 percent
 2132 exceedance lines. The reservoir elevations that would occur in the winter and early spring are
 2133 driven by the prolonged effect of the lower end of December elevation (from the *December*
 2134 *Libby Target Elevation* measure) or the drafts called for by the *Modified Draft at Libby* measure
 2135 (or both). It should be noted that MO3 targets a reservoir elevation of 2,400 feet NGVD29 at
 2136 the end of December (*December Libby Target Elevation* measure), but uses draft targets in
 2137 January, February and March set by an SRD (*Modified Draft at Libby* measure) designed to
 2138 accommodate an end-of-December elevation of 2,420 (NGVD29). The result of this combination
 2139 of measures is that in higher water supply years the reservoir is not drafted as deeply in January
 2140 through March as would be desired to achieve April FRM draft targets while striving for
 2141 relatively stable outflow.

2142 By April or May, the reservoir would generally begin refilling. The modified refill operation
2143 called for in the *Modified Draft at Libby* measure would generally improve the probability of
2144 refilling the reservoir, though in the driest years the reservoir would have less success in
2145 refilling (as compared to the No Action Alternative) due to the lower winter and early spring
2146 reservoir elevations that would occur. Overall, MO3 would have a 44 percent chance of the
2147 reservoir reaching elevation 2,454 feet NGVD29 or higher (within 5 feet of the full pool
2148 elevation of 2,459 feet NGVD29) by July 31, as compared to a 39 percent chance for the No
2149 Action Alternative. The peak reservoir elevation would usually be achieved in July or early
2150 August.

2151 During the months of August and September, the reservoir elevation for MO3 would generally
2152 be about 1 to 4 feet higher than for the No Action Alternative. The reason for this is the
2153 *Modified Draft at Libby* measure, which tends to increase the peak refill elevation, and the
2154 *Sliding Scale at Libby and Hungry Horse* measure which calls for a sliding scale end-of-
2155 September target elevation that would be dependent on the Libby Dam water supply forecast,
2156 rather than the system-wide water supply forecast at The Dalles. The *Sliding Scale at Libby and*
2157 *Hungry Horse* measure targets a higher elevation than the No Action Alternative in the wettest
2158 25 percent of years.

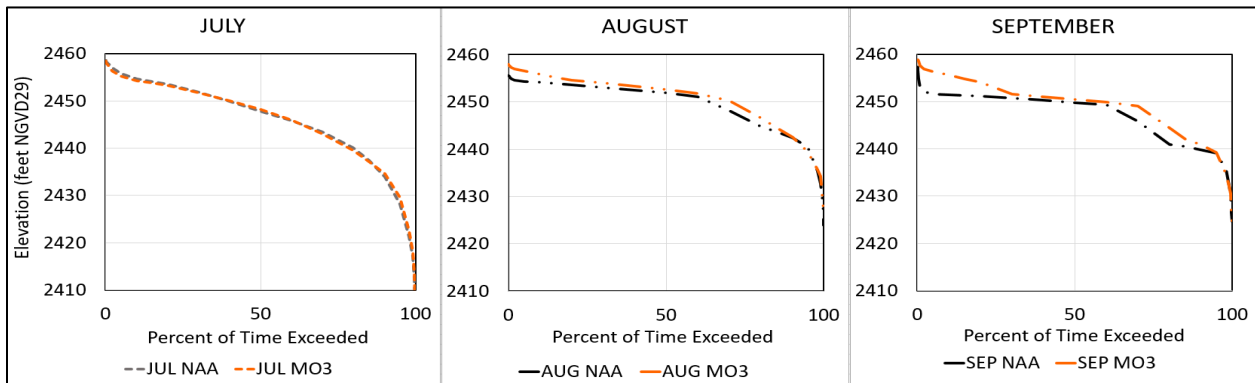
2159 As already discussed, the timing of and extent to which the reservoir elevation for MO3 would
2160 differ from the No Action Alternative would vary throughout the year. It is helpful to examine
2161 the changes that would occur based on the water year type, as shown in the median
2162 hydrographs for dry, average, and wet years in Figure 3-63. Dry years would see the most
2163 pronounced difference, with lower reservoir elevations beginning in November and December,
2164 and continuing through the winter and early spring, when they would be 20 to 25 feet lower
2165 than under the No Action Alternative. Average years would also have lower reservoir
2166 elevations, with the difference being most pronounced in the late fall and early winter months.
2167 Wet years would also differ, having lower reservoir elevations in November and December, and
2168 similar or higher elevations through the remainder of the water year.

2169 Finally, the three panels in Figure 3-64 show monthly elevation duration curves for July, August,
2170 and September, respectively. The curve for MO3 is plotted along with the curve for the No
2171 Action Alternative in each month. For July, the MO3 curve is virtually identical to the No Action
2172 Alternative. In August and September, the reservoir elevation under MO3 would tend to be the
2173 same or higher than the No Action Alternative. The higher elevations in August are due to the
2174 *Modified Draft at Libby* and the *Sliding Scale at Libby and Hungry Horse* measures. In
2175 September, they are due to the *Sliding Scale at Libby and Hungry Horse* measure, which has
2176 fewer years drafting to 2,439 feet NGVD29 than the No Action Alternative due to the change in
2177 forecast location, and the wettest years only needing a draft to 2,454 feet NGVD29.



2178
 2179
 2180

Figure 3-63. Lake Kocanusa Water Year Type Hydrographs for Multiple Objective Alternative 3

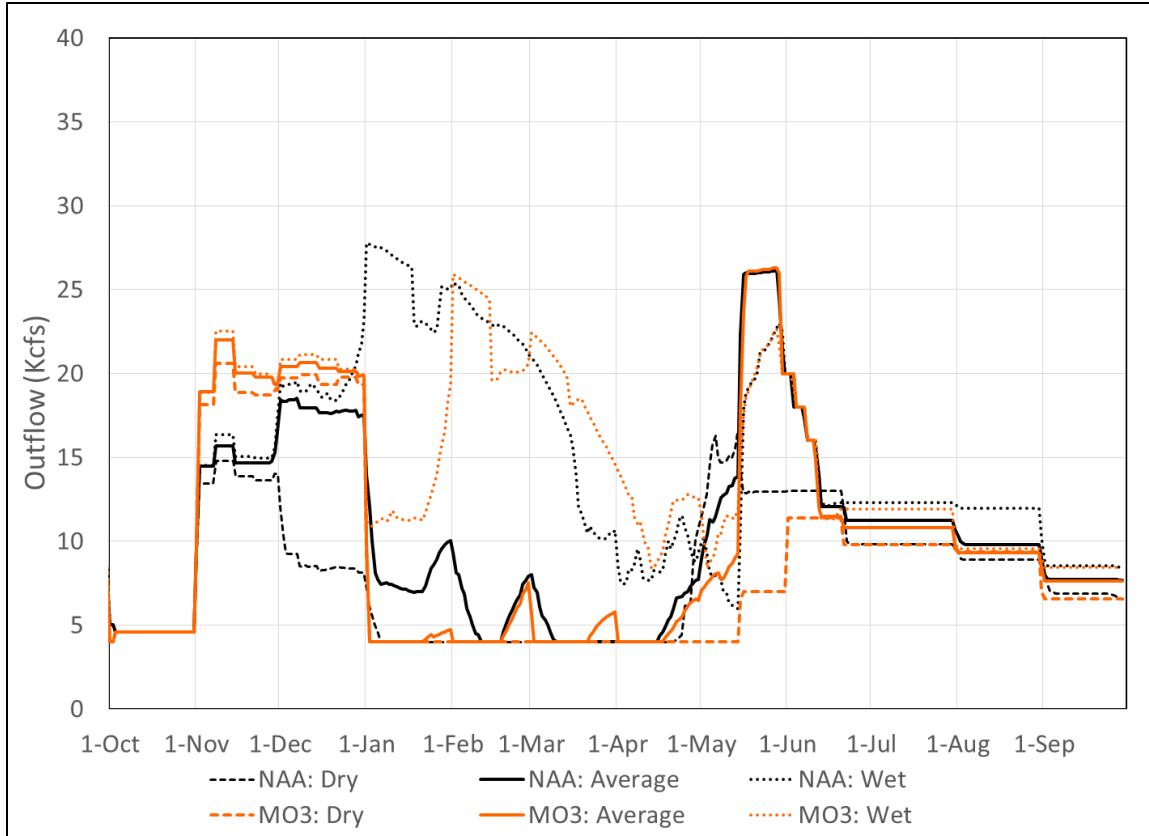


2181
 2182

Figure 3-64. Lake Kocanusa Summer Elevations for Multiple Objective Alternative 3

2183 Libby Dam Outflow

2184 Under MO3, the *Ramping Rates for Safety, Sliding Scale at Libby and Hungry Horse, Modified*
 2185 *Draft at Libby, and the December Libby Target Elevation* measures would have a direct effect on
 2186 Libby Dam outflow. The change in outflows from the No Action Alternative varies throughout
 2187 the year. Figure 3-65 shows median hydrographs for Libby Dam outflow in dry, average, and
 2188 wet years.



2189
 2190 **Figure 3-65. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 2191 **Alternative 3**

2192 Throughout the year, the *Ramping Rates for Safety* measure would allow for less restrictive
 2193 ramping rates, meaning that changes in outflow from Libby Dam (increases or decreases) could
 2194 be greater in magnitude than for the No Action Alternative. This measure would not discernibly
 2195 alter the monthly average outflow, but could change the outflow for a few days following a
 2196 sharp rise or drop in flow. It should be noted that the HEC-ResSim hydroregulation modeling
 2197 does not incorporate hourly, daily, or weekly load shaping at dams, including Libby Dam.

2198 The change in average monthly outflow throughout the water year is presented in Table 3-30.

2199 Average outflow from Libby Dam under MO3 would differ from the No Action Alternative:

- 2200 • In November and December, the monthly average outflows would increase. At the median
 2201 level, the increase in November would be 4.9 kcfs and the increase in December would be
 2202 2.4 kcfs. The December increases would be most pronounced in the lowest water supply
 2203 forecast years, with increases of 9.6 and 10.7 kcfs, respectively, at the 75 percent and 99
 2204 percent exceedance levels. The outflow increases are caused by the reservoir drafting to
 2205 elevation 2,400 feet NGVD29 in most years for hydropower, the result of the *December*
 2206 *Libby Target Elevation* measure.
- 2207 • In January through March, monthly average outflows would generally be the same or lower
 2208 than the No Action Alternative. At the median level, they would decrease by 3.7, 1.4, and

2209 0.6 kcfs, respectively. The lower outflow in January, and to a lesser extent in February and
2210 March of some years, is due to the way the *December Libby Target Elevation* measure
2211 combines with the *Modified Draft at Libby* measure.

- 2212 • Overall, April and May median monthly average outflows would decrease by 1.8 and 1.1
2213 kcfs, respectively, from the No Action Alternative. These changes are related to the VarQ
2214 update in the *Modified Draft at Libby* measure that would account for future volume
2215 releases and refill the reservoir more aggressively. During dry years, the larger decrease is
2216 from being drafted deeper in December for hydropower as part of the *December Libby
2217 Target Elevation* measure.
- 2218 • In June and July, monthly average outflows would generally be lower than the No Action
2219 Alternative. At the median level, they would decrease by 0.7 and 0.8 kcfs, respectively.
2220 However, the very highest releases under MO3 would be greater than those for the No
2221 Action Alternative.
- 2222 • In August and September, monthly average outflows would be lower than the No Action
2223 Alternative. At the median level, they would decrease by 0.9 and 0.4 kcfs, respectively. The
2224 *Sliding Scale at Libby and Hungry Horse* measure, calling for a sliding scale end-of-
2225 September target elevation based on the Libby Dam water supply forecast and a higher
2226 elevation target in the wettest 25 percent of years, contributes to this along with the
2227 improved refill from the *Modified Draft at Libby* measure.

2228 **Table 3-30. Libby Dam Monthly Average Outflow for Multiple Objective Alternative 3 (as**
2229 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	4.9	23.5	22.0	27.1	25.8	23.0	20.8	22.7	22.6	22.9	17.8	12.0
		25%	4.7	16.2	18.9	18.3	20.0	12.2	9.9	19.2	17.1	14.3	12.1	8.8
		50%	4.7	14.3	17.7	8.8	6.3	5.5	7.0	16.4	14.2	11.5	10.3	7.9
		75%	4.7	12.0	9.9	5.6	4.0	4.0	4.4	14.0	12.9	9.0	9.0	6.8
		99%	4.7	7.0	8.2	4.3	4.0	4.0	4.0	11.6	8.8	7.1	7.1	6.0
MO3	Change (kcfs)	1%	0.5	0.1	4.4	-5.4	-0.2	0.1	-1.0	-1.3	0.4	0.3	-3.3	0.1
		25%	-0.1	5.6	1.9	-7.6	-0.8	2.0	-0.2	-1.4	-0.9	-0.7	-1.1	-0.3
		50%	-0.1	4.9	2.4	-3.7	-1.4	-0.6	-1.8	-1.1	-0.7	-0.8	-0.9	-0.4
		75%	-0.1	4.2	9.6	-0.9	0.0	0.0	-0.4	-5.2	-0.6	0.0	0.0	-0.6
		99%	-0.1	3.7	10.7	0.3	0.0	0.0	0.0	-6.3	-2.2	-0.5	-0.5	0.0
	Percent change	1%	10%	0%	20%	-20%	-1%	0%	-5%	-6%	2%	1%	-19%	1%
		25%	-1%	35%	10%	-42%	-4%	17%	-2%	-7%	-5%	-5%	-9%	-3%
		50%	-1%	34%	14%	-42%	-22%	-11%	-26%	-7%	-5%	-7%	-9%	-5%
		75%	-1%	35%	97%	-16%	0%	0%	-9%	-37%	-4%	0%	0%	-8%
		99%	-1%	53%	131%	8%	0%	0%	0%	-54%	-25%	-7%	-7%	0%

2230 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO3 flows lower than the No
2231 Action Alternative flows; green shading denotes MO3 flows higher than the No Action Alternative flows.

2232 **Bonniers Ferry Flow**

2233 Under MO3, the *Ramping Rates for Safety, Sliding Scale at Libby and Hungry Horse*, Modified
2234 Draft at Libby, and *December Libby Target Elevation* measures would affect flows at Bonniers
2235 Ferry. In general, the flows would differ from the No Action Alternative in much the same way
2236 as at Libby Dam, and for the same reasons. The change in average monthly flow at Bonniers
2237 Ferry throughout the water year is presented in Table 3-31.

2238 **Table 3-31. Bonniers Ferry Monthly Average Flow for Multiple Objective Alternative 3 (as**
2239 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	9.0	26.6	29.2	31.3	29.7	27.5	30.4	40.8	40.7	27.2	19.0	13.3
		25%	6.1	18.1	20.7	21.0	23.2	15.3	19.4	34.3	27.8	17.3	13.3	9.7
		50%	5.6	15.4	18.9	10.4	8.5	8.4	14.6	31.1	23.8	14.6	11.4	8.6
		75%	5.4	13.0	11.4	6.5	5.1	5.9	10.2	27.6	20.3	11.8	9.9	7.4
		99%	5.1	7.7	9.0	5.1	4.5	4.9	7.0	18.3	12.6	9.0	8.1	6.7
MO3	Change (kcfs)	1%	0.6	1.3	1.7	-7.0	0.9	1.8	0.2	0.2	1.2	0.0	-3.5	0.8
		25%	-0.1	5.5	1.9	-8.6	-1.3	2.6	-0.6	-0.8	-0.7	-0.6	-1.1	-0.2
		50%	-0.1	4.9	2.6	-3.5	-1.3	-0.2	-1.0	-1.2	-0.7	-0.7	-0.8	-0.4
		75%	-0.1	4.5	9.0	-0.8	-0.1	-0.1	-0.5	-6.5	-0.7	-0.2	-0.3	-0.3
		99%	-0.1	3.8	10.7	0.3	0.0	0.0	0.0	-6.2	-2.9	-1.4	-0.9	-0.1
	Percent change	1%	7%	5%	6%	-22%	3%	7%	1%	0%	3%	0%	-18%	6%
		25%	-2%	31%	9%	-41%	-6%	17%	-3%	-2%	-2%	-4%	-8%	-2%
		50%	-1%	32%	14%	-34%	-16%	-2%	-7%	-4%	-3%	-5%	-7%	-5%
		75%	-1%	34%	79%	-12%	-2%	-2%	-5%	-24%	-3%	-2%	-3%	-4%
		99%	-1%	49%	119%	5%	0%	0%	0%	-34%	-23%	-15%	-11%	-2%

2240 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO3 flows lower than the No
2241 Action Alternative flows; green shading denotes MO3 flows higher than the No Action Alternative flows.

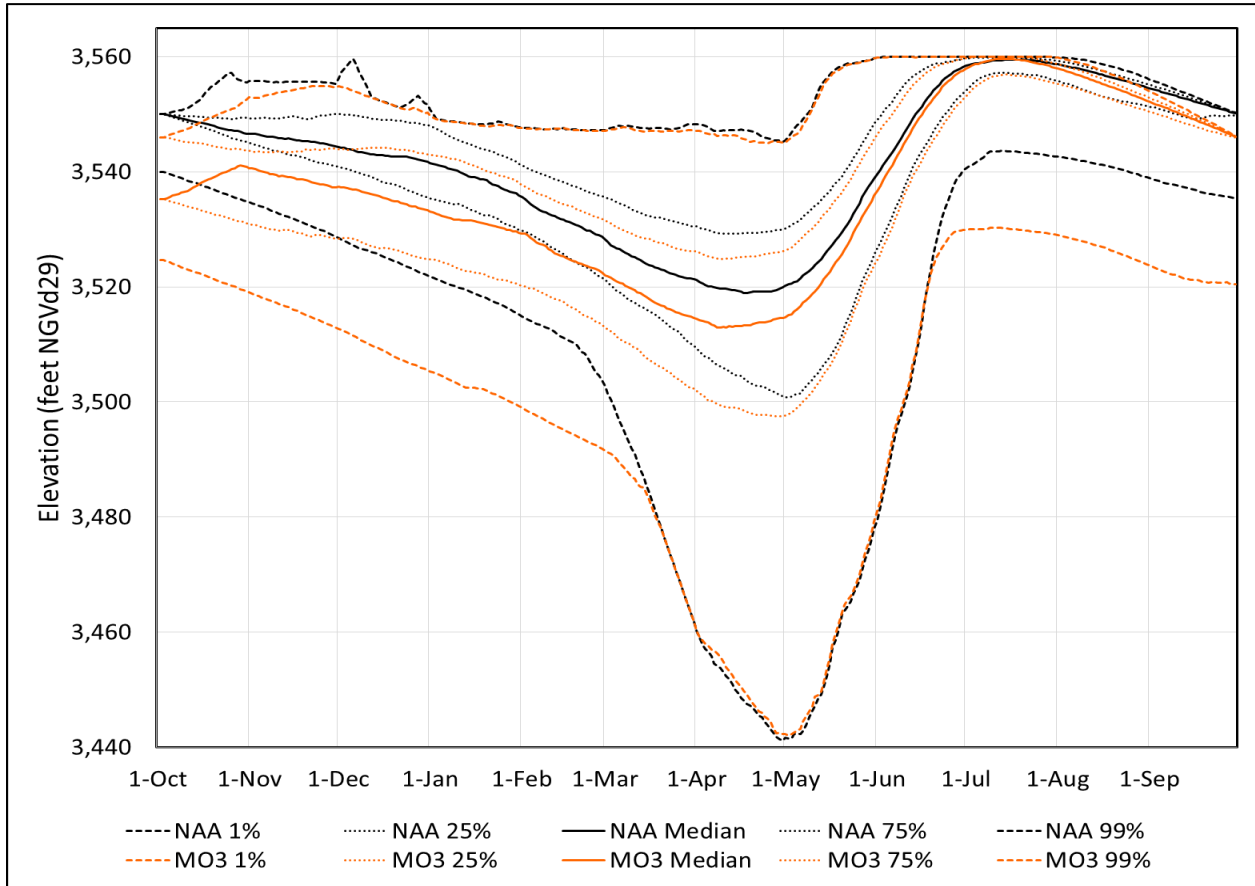
2242 **Hungry Horse Reservoir Elevation**

2243 Under MO3, the *Ramping Rates for Safety, Sliding Scale at Libby and Hungry Horse*, and *Hungry Horse*
2244 *Additional Water Supply* measures would have a direct effect on Hungry Horse Dam
2245 operations.

2246 Reservoir water levels would differ from the No Action Alternative, as shown in the summary
2247 hydrograph, Figure 3-66.

2248 The water year would begin with the reservoir levels for MO3 being lower than those for the
2249 No Action Alternative. This is because the operations associated with the *Hungry Horse*
2250 *Additional Water Supply* measure would leave the reservoir at a lower elevation on September
2251 30 than under the No Action Alternative, and the condition would carry over to the following
2252 water year. It should be noted that when MO3 was modeled, the initial Hungry Horse Reservoir
2253 levels at the start of each water year were erroneously set lower than intended. A subsequent
2254 sensitivity analysis revealed that this initialization error primarily affected results in the fall and
2255 winter. In the summary hydrograph, Figure 3-66, the median and higher elevations should have

2256 water levels 1 to 3 feet higher than shown from October through May. Below the median, the
 2257 results should be 5 to 10 feet higher from October through February.

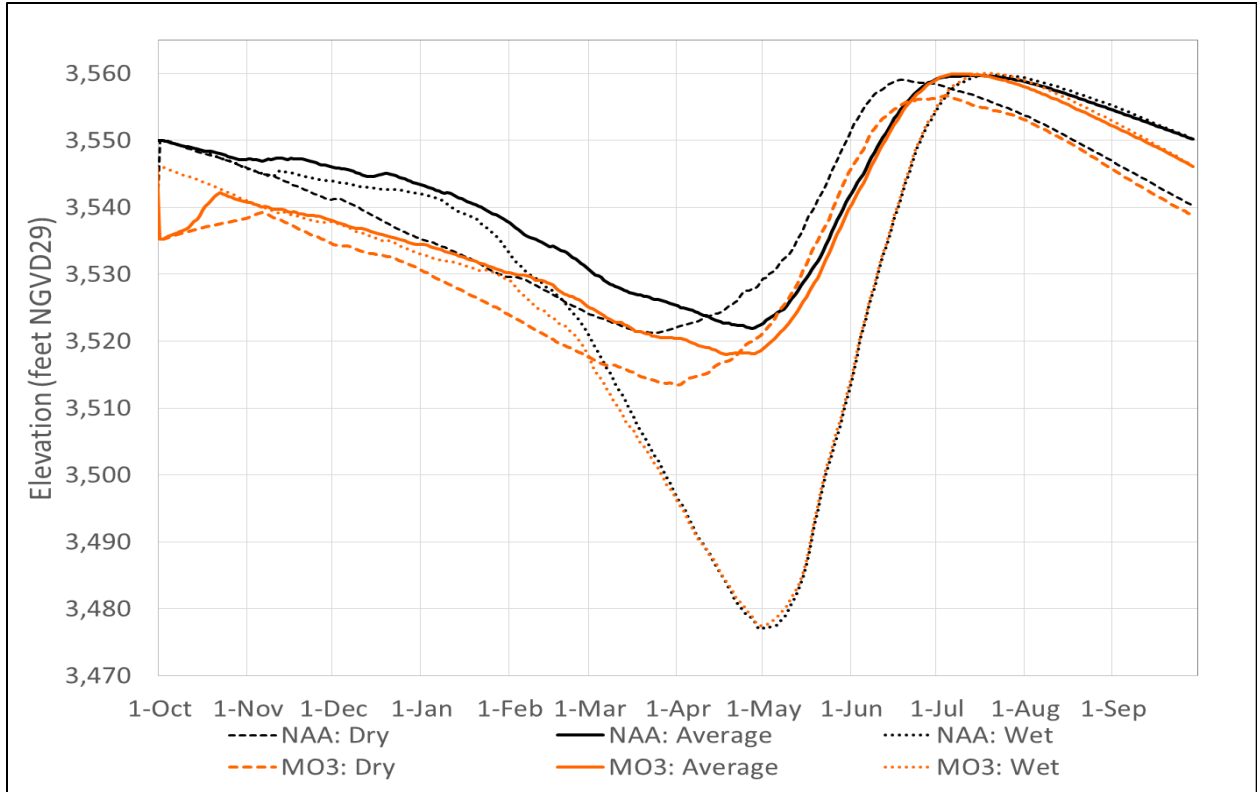


2258
 2259 **Figure 3-66. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative**
 2260 **3**

2261 This initialization error had little effect downstream from Hungry Horse Dam. Hungry Horse
 2262 Dam’s modeled releases were up to 1 kcfs lower than they should have been, but by the time
 2263 flow reaches Flathead Lake the MO3 results have little error.

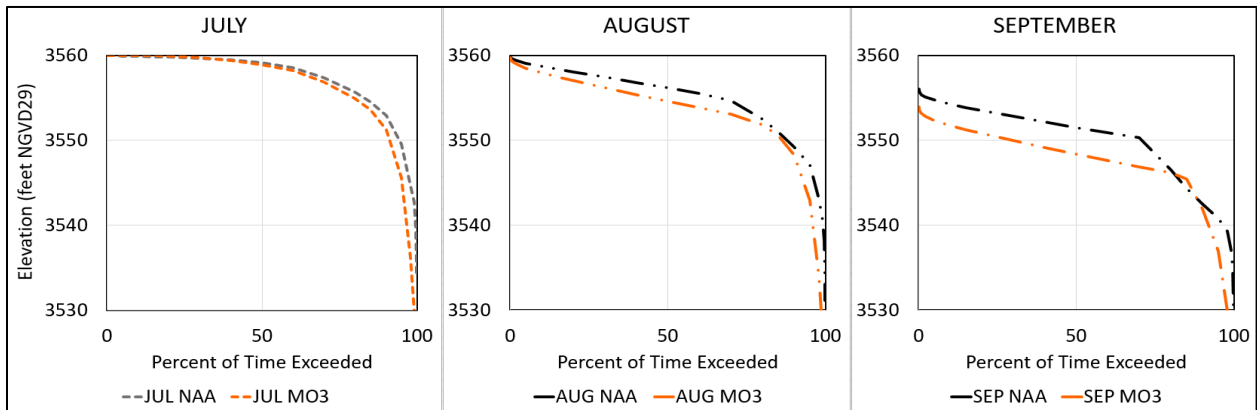
2264 Overall, reservoir elevations under MO3 would be lower than for the No Action Alternative. At
 2265 the median level, reservoir elevations would be about 4 feet lower in November through April
 2266 and 0 to 2 feet lower in May through August. By the end of September, reservoir levels under
 2267 MO3 would typically be 4 feet lower than the No Action Alternative. The *Sliding Scale at Libby*
 2268 *and Hungry Horse* measure results in reducing the draft requirements in some years, by setting
 2269 a higher elevation target for summer flow augmentation than the No Action Alternative.

2270 Water levels at Hungry Horse Reservoir under MO3 would differ from the No Action Alternative
 2271 to varying extents, depending on the water year type. Median hydrographs of the reservoir
 2272 level for dry, average, and wet years are shown in Figure 3-67.



2273
 2274 **Figure 3-67. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective**
 2275 **Alternative 3**

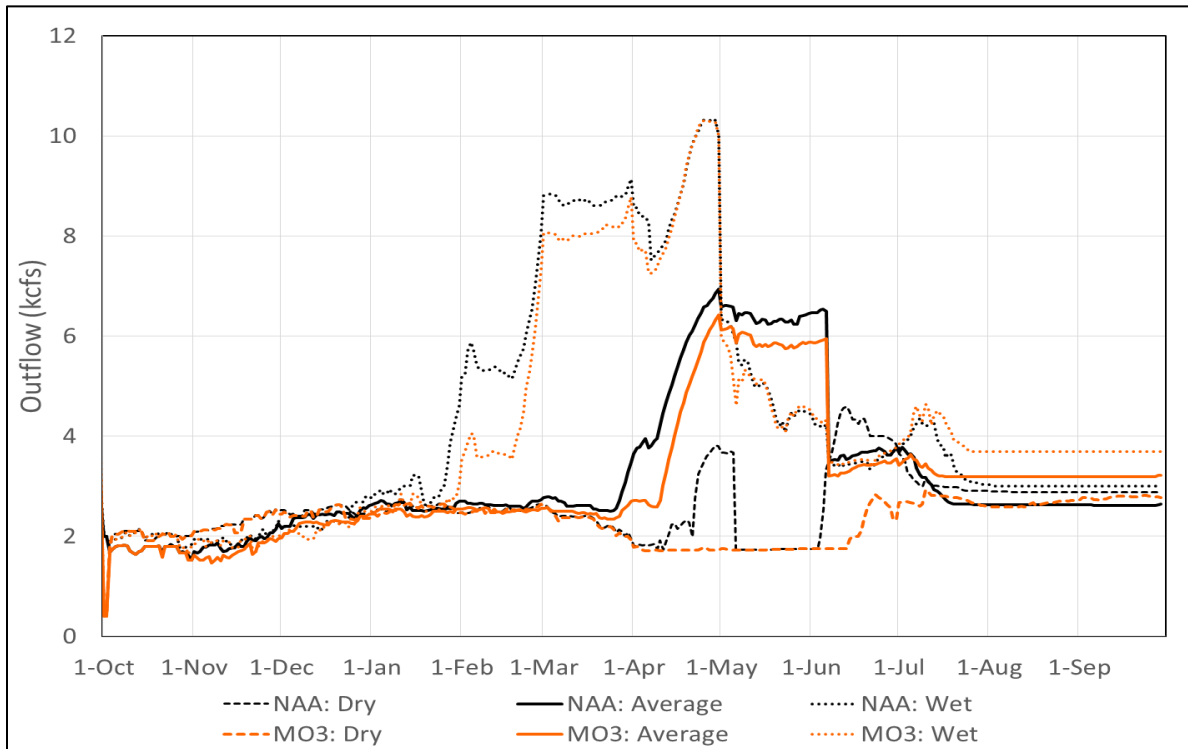
2276 Finally, the three panels in Figure 3-68 show Hungry Horse Reservoir elevation duration curves
 2277 for the months of July, August, and September, respectively. While other months have larger
 2278 differences, these three are shown because of interest in summer reservoir elevations. In
 2279 general, the reservoir levels under MO3 would be lower than for the No Action Alternative,
 2280 with August and September having the most difference. For instance, the daily reservoir
 2281 elevation in September would be above elevation 3,550 feet NGVD29 about 30 percent of the
 2282 time under MO3, whereas it would be above that elevation about 71 percent of the time under
 2283 the No Action Alternative.



2284
 2285 **Figure 3-68. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 3**

2286 **Hungry Horse Dam Outflow**

2287 Under MO3, the *Ramping Rates for Safety, Sliding Scale at Libby and Hungry Horse*, and *Hungry Horse Additional Water Supply* measures would have a direct effect on Hungry Horse Dam
2288 outflows. The outflows would differ from the No Action Alternative depending on the time of
2289 year. Figure 3-69 shows median hydrographs for Hungry Horse Dam outflow in dry, average,
2290 and wet years. Figure 3-69 shows median hydrographs for Hungry Horse Dam outflow in dry, average,
2291 and wet years.



2292 **Figure 3-69. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective**
2293 **Alternative 3**
2294

2295 The change in average monthly outflow from Hungry Horse Dam throughout the water year is
2296 presented in Table 3-32.

2297 **Table 3-32. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 3**
 2298 **(as change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	2.5	4.7	6.9	7.1	11.5	14.5	15.6	9.6	10.7	6.9	4.4	4.4
		25%	2.2	2.4	2.7	3.1	4.0	5.7	8.1	7.0	6.1	4.2	3.1	3.1
		50%	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7
		75%	1.4	1.4	2.1	2.3	2.4	2.2	3.1	4.1	3.2	2.6	2.4	2.4
		99%	0.8	0.8	1.6	2.0	1.7	1.5	1.7	1.7	1.7	1.7	1.8	1.9
MO3	Change (kcfs)	1%	-0.1	-0.8	-2.3	-0.7	-0.3	-0.3	-0.2	-0.1	-0.4	0.0	-0.1	-0.1
		25%	-0.1	-0.1	-0.2	-0.4	-0.9	-0.9	-0.4	-0.3	-0.4	0.1	0.5	0.5
		50%	-0.1	-0.1	-0.2	-0.1	-0.1	-0.2	-1.0	-0.4	-0.3	0.0	0.6	0.6
		75%	-0.2	-0.2	-0.3	-0.2	-0.1	-0.1	-0.6	-0.5	-0.4	0.2	0.4	0.5
		99%	-0.3	-0.2	-0.5	-0.4	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.2	0.3
	Percent change	1%	-4%	-18%	-33%	-10%	-2%	-2%	-1%	-1%	-4%	0%	-2%	-2%
		25%	-5%	-2%	-6%	-12%	-23%	-15%	-4%	-4%	-7%	2%	17%	17%
		50%	-7%	-6%	-6%	-3%	-5%	-7%	-19%	-8%	-8%	1%	21%	21%
		75%	-12%	-16%	-16%	-8%	-6%	-5%	-20%	-12%	-11%	9%	18%	19%
		99%	-39%	-29%	-32%	-17%	-12%	-7%	-3%	-1%	-3%	-3%	12%	17%

2299 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO3 flows lower than the No
 2300 Action Alternative flows; green shading denotes MO3 flows higher than the No Action Alternative flows.

2301 Average outflow from Hungry Horse Dam would differ from the No Action Alternative:

- 2302 • In August and September, the median value of the monthly average outflow would increase
 2303 as compared to the No Action Alternative. The measures driving these changes are the
 2304 *Hungry Horse Additional Water Supply* and *Sliding Scale at Libby and Hungry Horse*
 2305 measures.
- 2306 • After September and through the spring, reservoir outflows would generally be lower than
 2307 for the No Action Alternative. The lower outflows would occur because the reservoir would
 2308 be drafted deeper at the end of September, and so would begin the water year at a lower
 2309 elevation than under the No Action Alternative.

2310 While the initial Hungry Horse Reservoir levels at the start of each water year were erroneously
 2311 set lower than intended, the effects of this initialization on Hungry Horse discharge are smaller
 2312 than the effects on reservoir elevation. The results in Table 3-31 are close to what would be
 2313 expected for MO3. Winter flows would be lower than for the No Action Alternative, with flows
 2314 at the 1 percent exceedance level being the most underpredicted (the underprediction ranges
 2315 from 0.2 to 0.9 kcfs at the 1 percent exceedance level). By May and June, the underprediction
 2316 in flows from the initialization error is just 0.1 to 0.2 kcfs for most water year types. Moving
 2317 downstream through the system, flow effects from initialization have less and less of an effect
 2318 as the total river flows become larger and larger.

2319 Throughout the year, the *Ramping Rates for Safety* measure would allow for less restrictive
 2320 ramping rates, meaning that changes in outflow from Hungry Horse Dam (increases or

2321 decreases) could be greater in magnitude than for the No Action Alternative. This measure
2322 would not discernibly alter the monthly average outflow, but could change the outflow for a
2323 few days following a sharp rise or drop in flow. It should be noted that the HEC-ResSim
2324 hydroregulation modeling does not incorporate hourly, daily, or weekly load shaping at dams,
2325 including Hungry Horse Dam.

2326 **Columbia Falls Flow**

2327 Under MO3, the *Ramping Rates for Safety, Sliding Scale at Libby and Hungry Horse*, and *Hungry*
2328 *Horse Additional Water Supply* measures would affect flows at Columbia Falls. Compared to the
2329 No Action Alternative, there would be increased flow in August and September in virtually all
2330 years, while other months of the year would have flows similar to or less than those under the
2331 No Action Alternative, while still meeting minimum flow requirements. The change in average
2332 monthly flow at Columbia Falls throughout the water year, as compared to the No Action
2333 Alternative, is presented in Table 3-33.

2334 **Table 3-33. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 3 (as**
2335 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	8.9	14.4	14.8	11.0	14.2	17.4	30.5	38.0	43.2	23.9	8.8	8.7
		25%	4.0	4.2	4.5	5.0	5.8	7.9	15.9	29.7	31.5	15.1	6.9	5.4
		50%	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7
		75%	3.6	3.6	3.6	3.6	3.6	3.7	8.5	21.4	20.0	8.4	4.9	4.2
		99%	3.5	3.5	3.5	3.5	3.5	3.5	5.4	15.7	12.4	5.5	3.9	3.6
MO3	Change (kcfs)	1%	-1.7	-3.9	-3.5	-1.2	-0.5	-0.4	-0.3	-0.2	-0.1	0.0	0.7	-0.1
		25%	-0.2	-0.1	-0.7	-0.7	-1.0	-0.7	-0.5	-0.4	-0.1	0.3	0.5	0.6
		50%	-0.1	0.0	0.0	-0.1	-0.1	-0.5	-0.8	-0.3	-0.2	0.2	0.4	0.5
		75%	-0.1	0.0	0.0	0.0	0.0	-0.1	-0.7	-0.6	-0.5	0.0	0.3	0.4
		99%	-0.1	0.0	0.0	0.0	0.0	0.0	-0.4	-0.4	-0.5	-0.3	0.1	0.3
	Percent change	1%	-19%	-27%	-23%	-11%	-3%	-3%	-1%	-1%	0%	0%	8%	-1%
		25%	-4%	-3%	-14%	-15%	-17%	-9%	-3%	-1%	0%	2%	8%	11%
		50%	-4%	-1%	-1%	-2%	-3%	-10%	-6%	-1%	-1%	2%	7%	11%
		75%	-2%	0%	0%	0%	0%	-2%	-8%	-3%	-3%	0%	6%	8%
		99%	-3%	0%	0%	0%	0%	0%	-8%	-3%	-4%	-5%	1%	9%

2336 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO3 flows lower than the No
2337 Action Alternative flows; green shading denotes MO3 flows higher than the No Action Alternative flows.

2338 **Lake Pend Oreille Elevation**

2339 Under MO3, there are no measures that would have a direct effect on the level of Lake Pend
2340 Oreille. The operational changes at Hungry Horse Dam from the *Sliding Scale at Libby and*
2341 *Hungry Horse* and *Hungry Horse Additional Water Supply* measures would translate
2342 downstream (as flow changes) and pass through Lake Pend Oreille. The flow changes would not
2343 impact the annual peak reservoir levels and would not change the timing of refill or drawdown.

2344 Thus, there would not be any noticeable difference in the level of Lake Pend Oreille as
2345 compared to the No Action Alternative.

2346 **Albeni Falls Outflow**

2347 Under MO3, the *Sliding Scale at Libby and Hungry Horse* and *Hungry Horse Additional Water*
2348 *Supply* measures would affect the monthly average outflow from Albeni Falls Dam, but to a
2349 lesser degree than at Hungry Horse Dam or Columbia Falls. This is seen in Table 3-34.

2350 **Table 3-34. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 3 (as**
2351 **change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcsf)	Hungry Horse	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7
	Columbia Falls, MT	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7
	Albeni Falls	23.7	16.7	15.3	14.5	16.6	19.8	25.2	50.7	55.6	27.4	12.0	13.7
Change (kcsf)	Hungry Horse	-0.1	-0.1	-0.2	-0.1	-0.1	-0.2	-1.0	-0.4	-0.3	0.0	0.6	0.6
	Columbia Falls, MT	-0.1	0.0	0.0	-0.1	-0.1	-0.5	-0.8	-0.3	-0.2	0.2	0.4	0.5
	Albeni Falls	-0.9	-0.1	0.0	-0.1	-0.4	-0.2	-0.7	-0.5	-0.3	-0.3	0.0	-0.1
Percent Change	Hungry Horse	-7%	-6%	-6%	-3%	-5%	-7%	-19%	-8%	-8%	1%	21%	21%
	Columbia Falls, MT	-4%	-1%	-1%	-2%	-3%	-10%	-6%	-1%	-1%	2%	7%	11%
	Albeni Falls	-4%	-1%	0%	-1%	-3%	-1%	-3%	-1%	-1%	-1%	0%	-1%

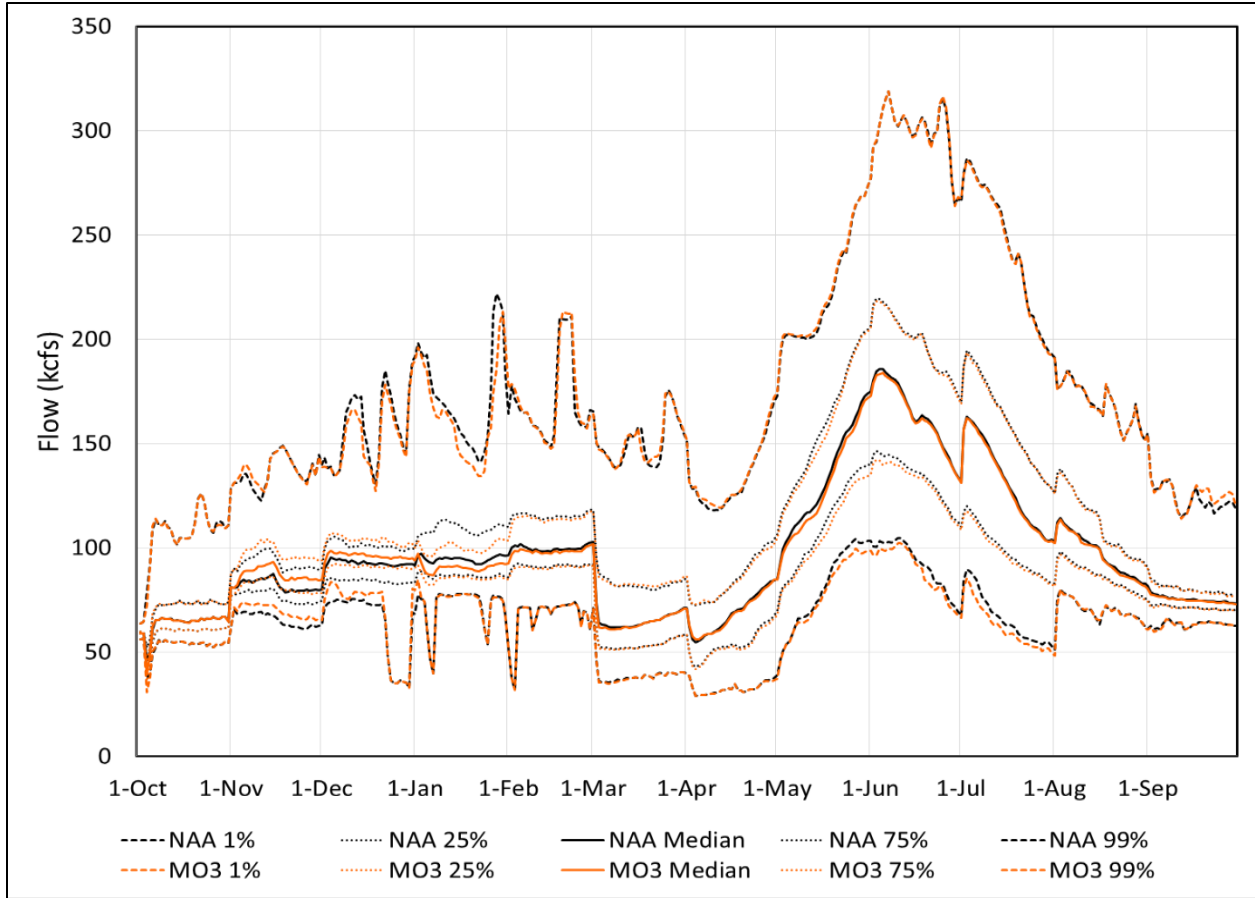
2352 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO3 flows lower than the No
2353 Action Alternative flows; green shading denotes MO3 flows higher than the No Action Alternative flows.

2354 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

2355 **Columbia River flow upstream of Grand Coulee Dam**

2356 Under MO3, the *Sliding Scale at Libby and Hungry Horse*, *Modified Draft at Libby*, *December*
2357 *Libby Target Elevation*, and *Hungry Horse Additional Water Supply* measures would affect
2358 Columbia River flow upstream of Grand Coulee Dam. A summary hydrograph of flows near RM
2359 748 (just downstream of the U.S.-Canada border, about 151 river miles upstream of Grand
2360 Coulee Dam) is shown in Figure 3-70.

2361 Figure 3-70 characterizes the timing and magnitude of flow changes between the No Action
2362 Alternative and MO3 due to the combined effect of measures at Libby and Hungry Horse Dams.
2363 Changes in flow between MO3 and the No Action Alternative would be noticeable in many
2364 months. In November and December, flows for MO3 would generally be higher, primarily due
2365 to the hydropower draft in in the *December Libby Target Elevation* measure at Libby Dam. In
2366 January, and again from May through July, MO3’s flows would generally be the same or lower.



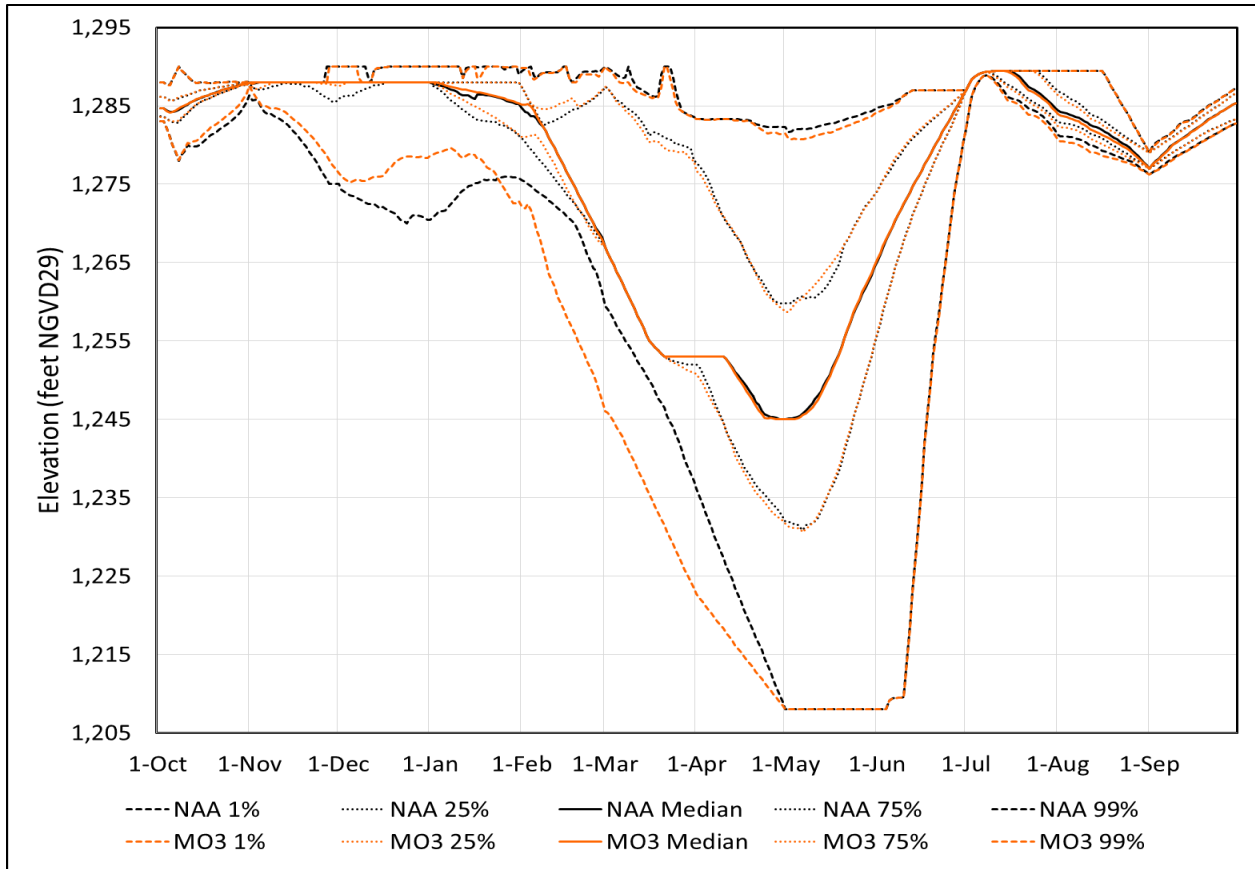
2367
 2368 **Figure 3-70. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 3**

2369 **Lake Roosevelt (Grand Coulee Dam Reservoir) Elevation**

2370 Under MO3, the *Update System FRM Calculation and Planned Draft Rate at Grand Coulee*
 2371 *measures* relate directly to Grand Coulee Dam and would influence reservoir elevations at Lake
 2372 Roosevelt.

2373 In addition, the *Sliding Scale at Libby and Hungry Horse, Modified Draft at Libby, December*
 2374 *Libby Target Elevation, and Hungry Horse Additional Water Supply* measures would affect the
 2375 inflow to Grand Coulee Dam. It is worth noting that MO3 does not have a measure calling for
 2376 winter FRM space at Grand Coulee Dam, whereas MO1, MO2, and MO4 all do have the *Winter*
 2377 *System FRM Space* measure. The hydroregulation modeling performed for MO3 incorporates all
 2378 of these measures, but because each measure was not evaluated in isolation from the others,
 2379 drawing a direct linkage between a single measure and an effect is not always possible. The
 2380 effects that would occur from a measure or combination of measures are identified and
 2381 discussed to the extent possible.

2382 Reservoir water levels in Lake Roosevelt under MO3 would differ from the No Action
 2383 Alternative, as shown in the summary hydrograph, Figure 3-71.



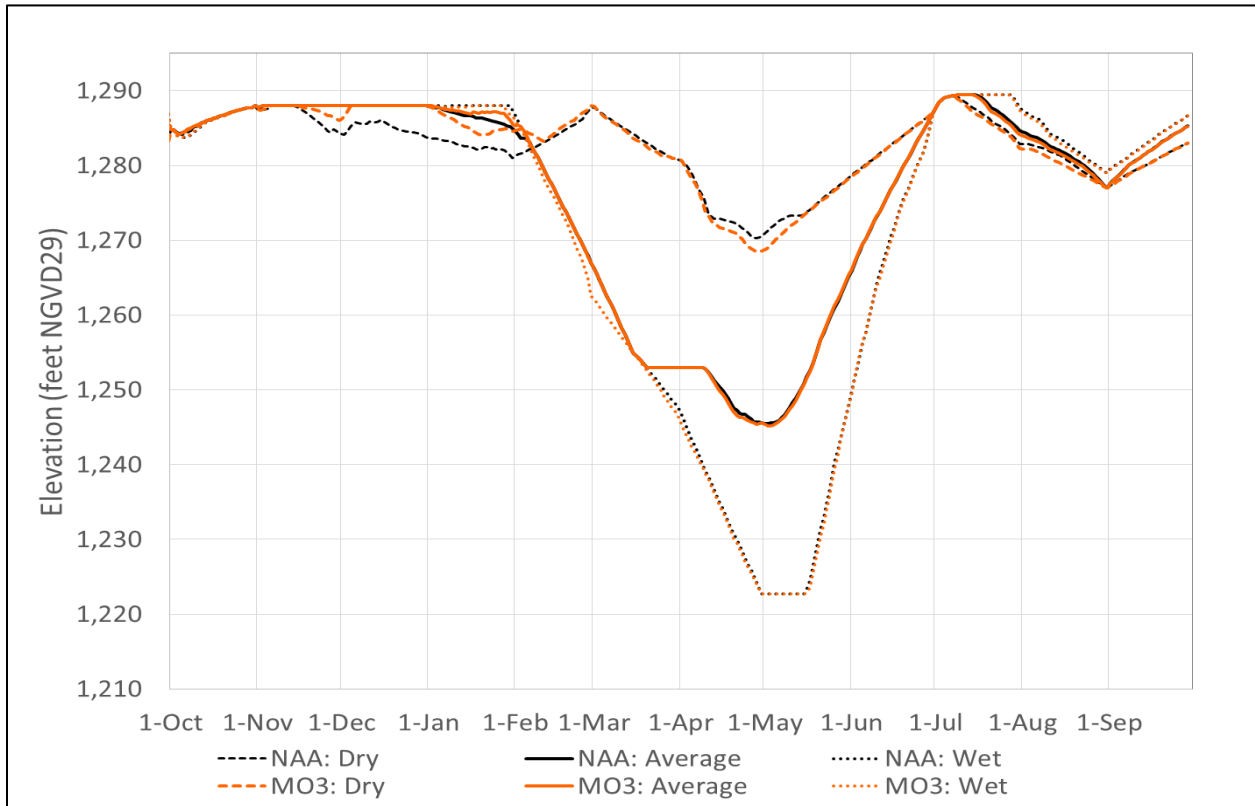
2384
2385

Figure 3-71. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 3

2386 Under MO3, the elevation of Lake Roosevelt throughout the year would be similar to the No
2387 Action Alternative, with a few exceptions as shown in Figure 3-71. In years with large water
2388 supply forecasts issued in the winter months, the reservoir elevation would be lower in the
2389 winter and early spring primarily due to the *Planned Draft Rate at Grand Coulee* and *Update*
2390 *System FRM Calculation* measures. These measures work together to achieve FRM space
2391 requirements at Grand Coulee Dam based on water supply conditions. The *Update System FRM*
2392 *Calculation* measure determines how much space is needed at Grand Coulee Dam, given the
2393 amount of space available elsewhere in the system; the *Planned Draft Rate at Grand Coulee*
2394 measure determines how early to start drafting the reservoir to achieve that space. The *Update*
2395 *System FRM Calculation* measure would also have an influence on reservoir elevations in the
2396 winter and spring months. *Grand Coulee Maintenance Operations* and *Lake Roosevelt*
2397 *Additional Water Supply* measures would not have an effect on the reservoir elevation, but
2398 would affect outflow from the dam, including the amount of outflow that would occur as spill.

2399 MO3 has a similar probability of drafting to very low reservoir elevations (elevation 1,222 feet
2400 NGVD29 or below) at Lake Roosevelt on April 30 as the No Action Alternative. This is because
2401 the FRM space requirement at Grand Coulee Dam defined in the *Update System FRM*
2402 *Calculation* measure retains a “flat spot” at elevation 1,222.7 feet NGVD29, similar to the No
2403 Action Alternative.

2404 Finally, median hydrographs for Lake Roosevelt elevation in dry, average, and wet years are
 2405 shown in Figure 3-72. The figure provides another way to picture the effects of MO3, this time
 2406 categorized by water year type. Presented this way, it can be seen that in dry years, Lake
 2407 Roosevelt’s elevation from mid-November through early February would be higher under MO3
 2408 than the No Action Alternative. From mid-November through the end of December, this is
 2409 caused by higher inflows to Grand Coulee Dam, rather than a change in operations at Grand
 2410 Coulee Dam itself.



2411
 2412 **Figure 3-72. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative**
 2413 **3**

2414 **Grand Coulee Dam Drum Gate Maintenance**

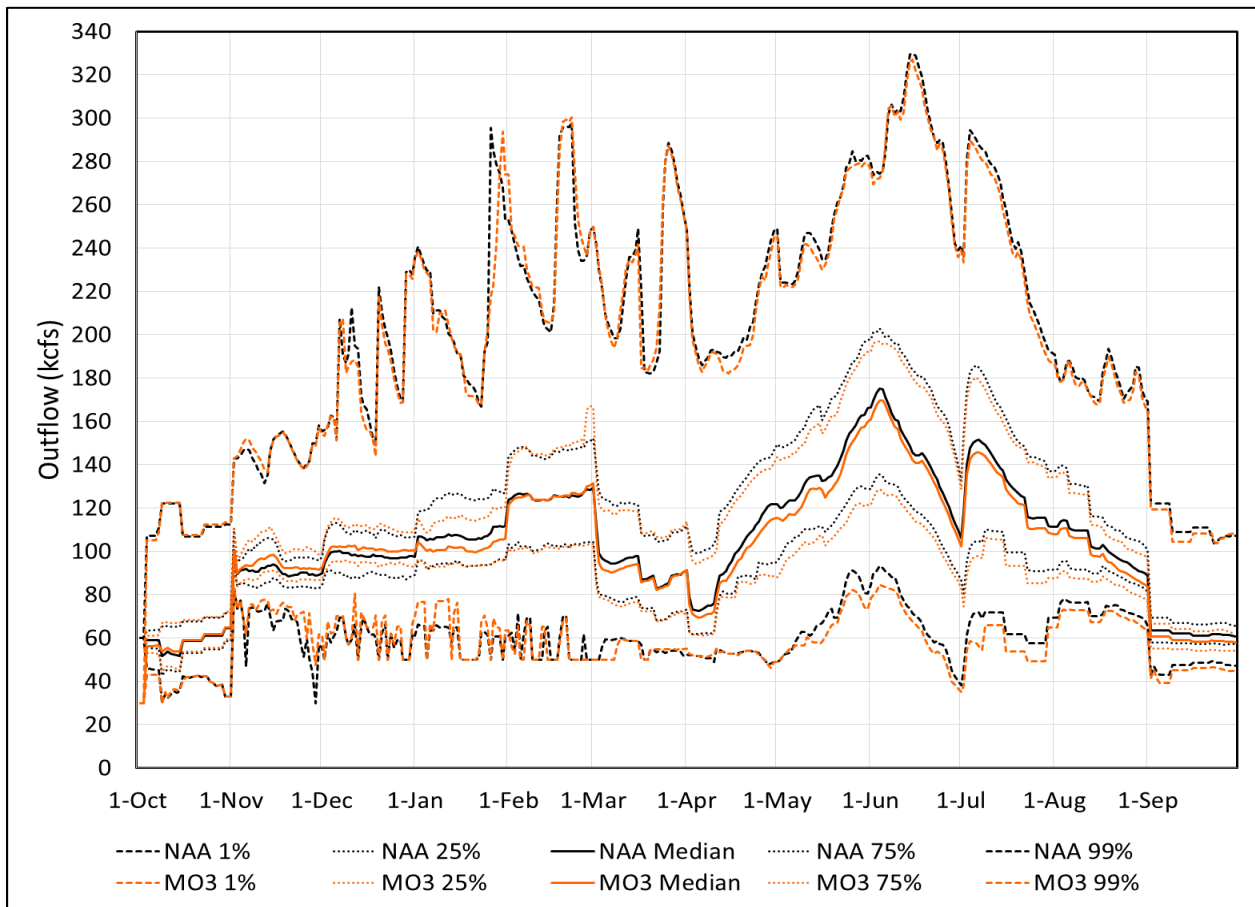
2415 Drum gate maintenance at Grand Coulee Dam is planned to occur annually during March, April,
 2416 and May, but is not conducted in all years. The reservoir must be at or below elevation 1,255
 2417 feet NGVD29 for 8 weeks to complete drum gate maintenance. Under MO3, the *Update System*
 2418 *FRM Calculation*, and *Planned Draft Rate at Grand Coulee* measures would influence reservoir
 2419 elevations during spring months.

2420 The changes in elevations for MO3 that influence the decision to conduct drum gate
 2421 maintenance would not change significantly relative to the No Action Alternative (April 30 FRM
 2422 elevation targets and drum gate initiation methodology is discussed in more detail in Part 1 of
 2423 Appendix B). The decision to conduct drum gate maintenance is based on the February water
 2424 supply forecast and the resulting April 30 FRM elevation projection (April 30 FRM elevation

2425 target at or below 1,255 or 1,265 feet NGVD29 depending on how recently the maintenance
 2426 has been conducted). This is not to say the spring elevations are the same for the two
 2427 alternatives but rather there are a similar number of years that elevations would allow for drum
 2428 gate maintenance. In both MO3 and the No Action Alternative, drum gate maintenance would
 2429 be achievable in 65 percent of the years.

2430 **Grand Coulee Dam Outflow**

2431 Under MO3, the *Update System FRM Calculation, Planned Draft Rate at Grand Coulee, and Lake*
 2432 *Roosevelt Additional Water Supply* measures would directly affect outflows from Grand Coulee
 2433 Dam. In addition, the *Sliding Scale at Libby and Hungry Horse, Modified Draft at Libby,*
 2434 *December Libby Target Elevation and Hungry Horse Additional Water Supply* measures would
 2435 affect inflows and outflows at Grand Coulee Dam. The outflows from Grand Coulee Dam would
 2436 differ from the No Action Alternative depending on the time of year, as seen in the summary
 2437 hydrograph, Figure 3-73.



2438 **Figure 3-73. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective**
 2439 **Alternative 3**
 2440

2441 The change in average monthly outflow throughout the water year is presented in Table 3-35.

2442 **Table 3-35. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 3**
2443 **(as change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	94	130	174	190	213	186	191	231	275	247	175	111
		25%	67	99	109	124	147	117	120	165	181	158	118	68
		50%	59	91	97	108	126	93	97	138	150	134	102	63
		75%	54	84	88	96	105	78	79	118	121	98	92	59
		99%	49	78	79	76	81	66	60	97	91	81	81	53
MO3	Change (kcfs)	1%	-1.7	0.5	-4.5	-3.8	6.1	-0.6	-8.0	-5.6	-1.0	-5.2	-3.3	-2.9
		25%	-1.9	3.4	1.7	-8.7	1.5	-0.4	-3.8	-6.6	-3.6	-4.0	-4.8	-3.0
		50%	-1.8	2.2	3.7	-5.4	0.1	-2.3	-4.8	-6.7	-4.8	-4.6	-3.9	-3.2
		75%	-1.8	3.9	5.9	0.2	-1.9	-1.8	-2.6	-7.0	-5.2	-5.6	-4.7	-2.9
		99%	-1.7	3.9	4.9	9.7	0.9	-0.3	0.0	-8.0	-7.5	-5.7	-4.1	-2.9
	Percent change	1%	-2%	0%	-3%	-2%	3%	0%	-4%	-2%	0%	-2%	-2%	-3%
		25%	-3%	3%	2%	-7%	1%	0%	-3%	-4%	-2%	-3%	-4%	-4%
		50%	-3%	2%	4%	-5%	0%	-2%	-5%	-5%	-3%	-3%	-4%	-5%
		75%	-3%	5%	7%	0%	-2%	-2%	-3%	-6%	-4%	-6%	-5%	-5%
		99%	-3%	5%	6%	13%	1%	0%	0%	-8%	-8%	-7%	-5%	-6%

2444 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO3 flows lower than the No
2445 Action Alternative flows; green shading denotes MO3 flows higher than the No Action Alternative flows.

2446 Under MO3, the *Lake Roosevelt Additional Water Supply* measure calls for an increased volume
2447 of water to be pumped from Lake Roosevelt into Banks Lake, which would directly affect Grand
2448 Coulee Dam outflows. Because several other measures in MO3 would also affect Grand Coulee
2449 Dam’s outflow, the effects of MO3 are described below, identifying the measure (or
2450 combination of measures) responsible for the change where possible.

- 2451 • In November, the median value of the monthly average outflow would increase by 2.2 kcfs.
2452 This is due to the hydropower draft in the *December Libby Target Elevation* measure.
- 2453 • In December, the median value of the monthly average outflow would increase by 3.7 kcfs.
2454 This is again attributable to the *December Libby Target Elevation* measure. However, for the
2455 highest flows (1 percent exceedance levels), the monthly average outflow would decrease.
- 2456 • In January, the median value of the monthly average outflow would decrease by 5.4 kcfs. At
2457 other exceedance levels, there would be flow changes of greater magnitude, some higher
2458 than the No Action Alternative and some lower. The outflow decrease is primarily caused by
2459 reduced outflow from Libby Dam.
- 2460 • In February, the median value of the monthly average outflow would be similar to the No
2461 Action Alternative (0.1 kcfs modeled increase). However, other exceedance levels would
2462 have changes of greater magnitude, some higher than the No Action Alternative and some
2463 lower.
- 2464 • In March, the median value of the monthly average outflow would decrease by 2.3 kcfs due
2465 to outflow changes from Libby and Hungry Horse Dams and the additional water supply

2466 from Lake Roosevelt. In March the measure *Lake Roosevelt Additional Water Supply* would
2467 reduce flows approximately 0.6 kcfs.

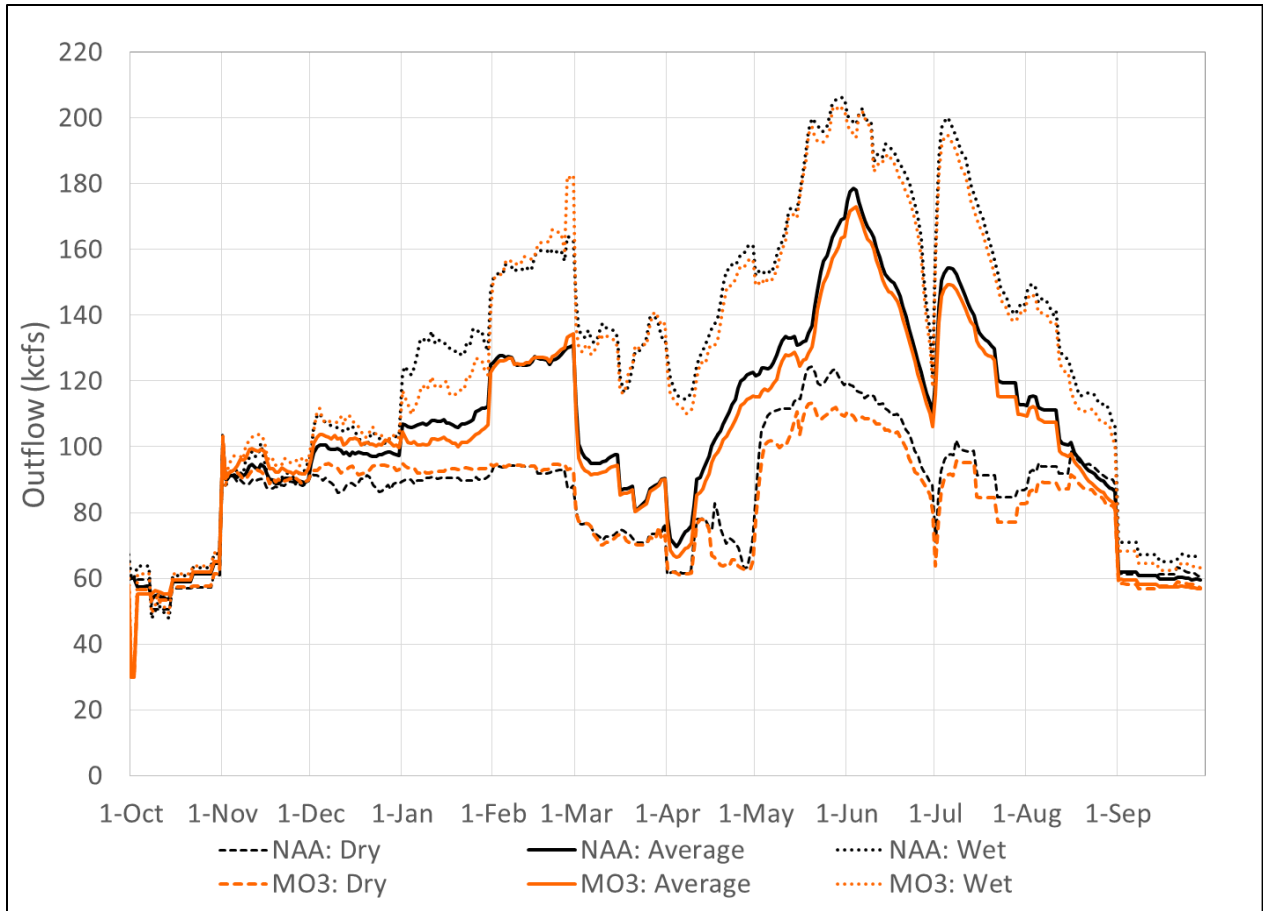
2468 • In April the volume of water to be pumped from Lake Roosevelt into Banks Lake as a result
2469 of the *Lake Roosevelt Additional Water Supply* measure would increase. The April through
2470 September period would have the greatest total pumping volumes, as well as the greatest
2471 additional pumping volumes as called for in the *Lake Roosevelt Additional Water Supply*
2472 measure.

2473 • In April, May, and June, the monthly average outflows would consistently be lower. At the
2474 median level, they would decrease by 4.8, 6.7, and 4.8 kcfs, respectively. These changes are
2475 largely due to the *Lake Roosevelt Additional Water Supply* measure and changes to inflows
2476 from projects upstream (Libby and Hungry Horse Dams), though other measures also have
2477 an influence. In April, May and June the measure *Lake Roosevelt Additional Water Supply*
2478 would reduce flows approximately 3.2, 3.2, and 3.0 kcfs respectively.

2479 • In July, August, and September, monthly average outflows would also be consistently lower.
2480 At the median level, the monthly average outflow for July, August, and September would be
2481 reduced by 4.6, 3.9, and 3.2 kcfs, respectively. These changes are predominantly due to the
2482 *Lake Roosevelt Additional Water Supply* measure. The *Lake Roosevelt Additional Water*
2483 *Supply* measure would decrease flows by 4.2, 2.6, and 2.5 kcfs in July, August, and
2484 September respectively.

2485 • The *Grand Coulee Maintenance Operations* measure would not impact reservoir elevations
2486 or total outflows, but would reduce the hydraulic capacity through the power plants,
2487 resulting in additional spill and an increase in TDG in some situations.

2488 Finally, median hydrographs for Grand Coulee Dam outflow in dry, average, and wet years are
2489 shown in Figure 3-74. MO3 and the No Action Alternative are shown. The figure provides
2490 another way to picture the effects described above, this time categorized by water year type.



2491
 2492 **Figure 3-74. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 2493 **Alternative 3**

2494 **Middle Columbia River below Grand Coulee Dam**

2495 Under MO3, the pattern of flow changes in the middle Columbia River would be similar to those
 2496 described for Grand Coulee Dam outflow, with the changes occurring for the same reasons as
 2497 described for Grand Coulee Dam outflow. An additional measure, *Chief Joseph Dam Project*
 2498 *Additional Water Supply*, calls for an increase in water diversion (at a maximum rate of 0.05
 2499 kcf) from the Columbia River for the Chief Joseph Dam. The total flow impact from the *Chief*
 2500 *Joseph Dam Project Additional Water Supply* measure is 9.6 kaf annually, which is significantly
 2501 smaller than the impacts from the *Lake Roosevelt Additional Water Supply* measure that
 2502 reduces flows an additional 1.1 Maf annually. For perspective, the flow change for the *Chief*
 2503 *Joseph Dam Project Additional Water Supply* measure is two orders of magnitude smaller than
 2504 that for the *Lake Roosevelt Additional Water Supply* measure. The reservoir elevation at Chief
 2505 Joseph Dam would not change from the No Action Alternative.

2506 Table 3-36 shows changes in the median values of monthly average flows at locations in the
 2507 middle Columbia River.

2508 **Table 3-36. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative**
2509 **3 (as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcfs)	Lake Roosevelt Inflow	64	82	92	95	100	65	69	131	166	133	98	75
	Grand Coulee	59	91	97	108	126	93	97	138	150	134	102	63
	Chief Joseph	58	91	96	108	127	94	98	139	150	135	103	63
	Wells	59	93	98	110	129	95	101	150	163	141	105	65
	Priest Rapids	60	96	102	115	133	100	108	162	178	147	108	68
Change (kcfs)	Lake Roosevelt Inflow	-0.2	5.4	4.3	-3.4	-1.4	-0.5	-1.2	-3.3	-0.8	-0.7	-0.4	-0.3
	Grand Coulee	-1.8	2.2	3.7	-5.4	0.1	-2.3	-4.8	-6.7	-4.8	-4.6	-3.9	-3.2
	Chief Joseph	-1.2	2.2	3.7	-5.2	0.0	-2.3	-4.7	-6.8	-4.6	-4.8	-3.8	-3.0
	Wells	0.1	2.1	4.1	-5.0	-0.2	-2.1	-4.6	-7.2	-4.7	-5.0	-3.7	-3.0
	Priest Rapids	0.1	3.0	4.7	-5.0	-0.5	-1.9	-4.7	-7.1	-4.4	-4.3	-3.5	-3.0
Percent Change	Lake Roosevelt Inflow	0%	7%	5%	-4%	-1%	-1%	-2%	-2%	0%	-1%	0%	0%
	Grand Coulee	-3%	2%	4%	-5%	0%	-2%	-5%	-5%	-3%	-3%	-4%	-5%
	Chief Joseph	-2%	2%	4%	-5%	0%	-2%	-5%	-5%	-3%	-4%	-4%	-5%
	Wells	0%	2%	4%	-5%	0%	-2%	-5%	-5%	-3%	-4%	-3%	-5%
	Priest Rapids	0%	3%	5%	-4%	0%	-2%	-4%	-4%	-2%	-3%	-3%	-4%

2510 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO3 flows lower than the No
2511 Action Alternative flows; green shading denotes MO3 flows higher than the No Action Alternative flows.

2512 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
2513 **HARBOR DAMS**

2514 **Dworshak Dam**

2515 MO3 does not have any operational measures that would directly affect Dworshak Reservoir
2516 elevations or Dworshak Dam outflows. Given this, the effects would be the same as those for
2517 the No Action Alternative, though the *Ramping Rates for Safety* measure, which allows for less
2518 restrictive ramping rates, could result in greater hourly or daily outflow changes at Dworshak
2519 Dam, as well as the other CRS dams.

2520 **Clearwater and Snake Rivers below Dworshak Dam**

2521 Under MO3, the *Breach Snake Embankments* measure calls for the breaching of the four lower
2522 Snake River dams by removing earthen embankments and adjacent structures. This measure
2523 would result in dramatic changes in hydraulic conditions (water level, depth, channel width,
2524 velocity, etc.) and seasonal water level dynamics in the lower Snake River from several miles
2525 above the confluence of the Snake with the Clearwater River near Lewiston, Idaho, to the
2526 location of Ice Harbor Dam. Changes to flow amounts would be minor since the four lower
2527 Snake River dams are run-of-river projects, not storage projects. Compared to the No Action
2528 Alternative where transitions to or from MOP operations occur in late March and early
2529 September, MO3 would result in monthly average flow changes below Ice Harbor Dam of -0.9
2530 kcfs in the March and +1.3 kcfs in September. The latter can result in and up to 8 percent
2531 increase in average monthly September flow in low water years.

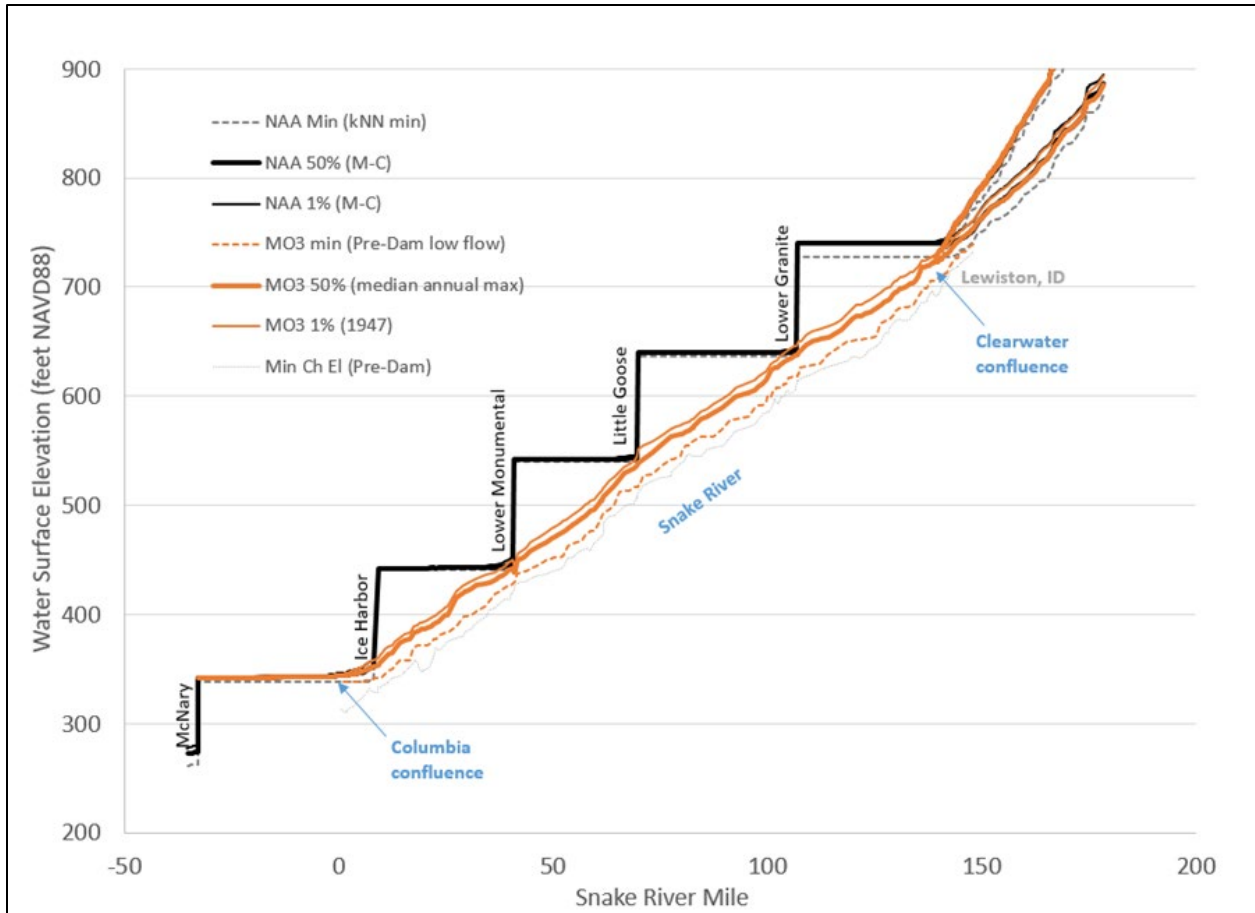
2532 Also, changes in irrigation withdrawals were not included in the Reservoir Operations model
2533 but are discussed in Section 3.12, the Water Supply section of this EIS. It is expected that
2534 irrigation withdrawals from the lower Snake River reach could be decreased by over 200 KAF
2535 through the irrigation season, and this would translate to a small (less than 1 kcfs) but
2536 sometimes noticeable increase in total Snake River flows compared to the No Action
2537 Alternative from April 1 to October 15. The increase in Snake River flow below Ice Harbor would
2538 typically be less than 1 percent, but could be as large as 4 percent in late summer during dry
2539 years, and the flow change downstream in the Columbia would be negligible. These changes
2540 would be in addition to the reported changes described in Table 3-35.

2541 The H&H Appendix (Appendix B, Part 1, *H&H Data Analysis*) also contains greater detail on
2542 expected water conditions than the information presented here.

2543 Figure 3-75 shows a comparison of water surface profiles for the lower Snake River reaches
2544 (from McNary Dam to beyond Lewiston, Idaho). The water surface profile for MO3 generally
2545 follows the slope of the riverbed, whereas the water surface profile for the No Action
2546 Alternative appears as a stair step, due to the presence of the dams and the reservoirs they
2547 impound. The *Breach Snake Embankments* measure would cause the depth of water in the river
2548 to be as much as 100 feet less at locations just upstream of the four lower Snake River dam
2549 sites. Seasonal fluctuations in water level would increase from less than 5 feet under the No
2550 Action Alternative to 10 to 15 feet (typical) under MO3.

2551 Under MO3, changes in river width would also occur. The average decrease in width would be
2552 about 500 feet, but the change could be as much as a half mile in some locations. The decrease
2553 in width would generally be the most pronounced in locations closest to the dams, although
2554 this is not the case with Little Goose Reservoir, which has the widest section a few miles
2555 upstream from the dam, near RM 75.

2556 Other changes in river hydraulics include dramatic increases in average and minimum hydraulic
2557 grade (slope) and increases in average and minimum velocity. Without the reservoirs, the water
2558 particle travel time through the reach could be reduced by an order of magnitude. These
2559 changes are described in greater detail in the H&H Appendix (Appendix B, Part 1, *H&H Data
2560 Analysis*). The River Mechanics section of this EIS (Section 3.3, *River Mechanics*) presents
2561 information on the changes in river hydraulics that would occur as a result of this measure,
2562 including sediment transport and channel morphology. Further details are also provided in the
2563 River Mechanics Appendix (Appendix C), which describes the channel conditions that would be
2564 expected several years following dam breach, after fluvial processes have had time to move
2565 accumulated sediment and allow for the river channel to reach a relatively stable, equilibrium
2566 state. Changes in hydrologic routing through the reach would be minor.



2567
 2568 **Figure 3-75. Lower Snake River Water Surface Profiles for Multiple Objective Alternative 3**

2569 **REGION D – McNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

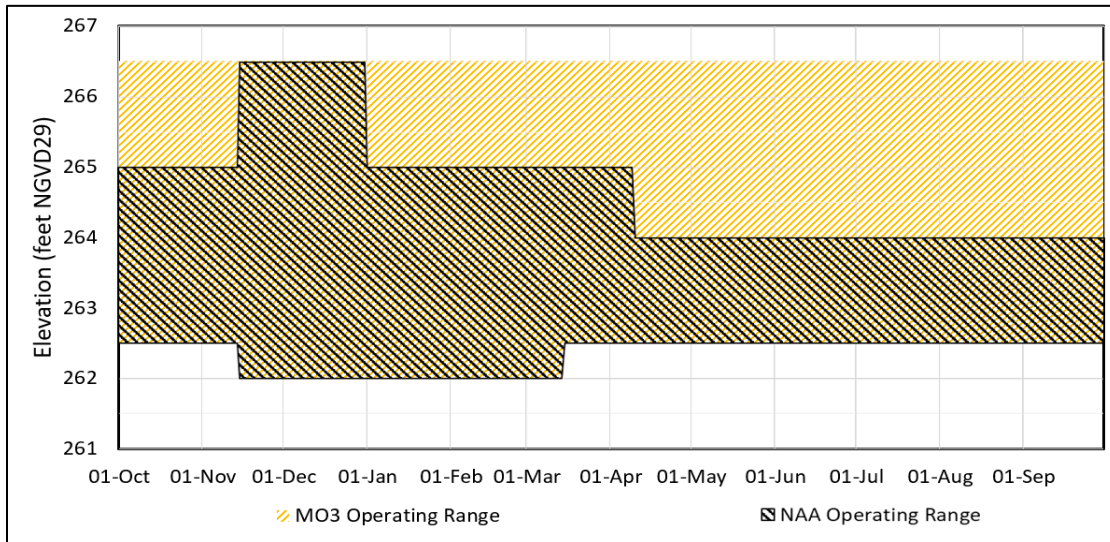
2570 **Lower Columbia River Reservoir Elevations**

2571 Under MO3, there would be no changes to the reservoir elevations at McNary Dam, The Dalles
 2572 Dam, or Bonneville Dam. At John Day Dam, the *John Day Full Pool* measure calls for operating
 2573 the reservoir in a range between 262.5 feet NGVD29 and 266.5 feet NGVD29 year round,
 2574 except as needed for FRM. When operation is needed for FRM, the full operating range (257.0
 2575 to 268.0 feet NGVD29) may be used, as is the case for the No Action Alternative. The operating
 2576 elevation range changes and changes in elevation maximum and minimum elevations as
 2577 compared to No Action Alternative are described below:

- 2578 • January 1 to March 14: Compared to the No Action Alternative (262.0 and 265.0 feet
 2579 NGVD29), the minimum and maximum elevations are increased by 0.5 foot and 1.5 feet,
 2580 respectively, increasing the overall range from 3.0 to 4.0 feet.
- 2581 • March 15 to April 9 and October 1 to November 14: Compared to the No Action Alternative
 2582 (262.5 and 265.0 feet NGVD29), the overall range and maximum elevation is increased by
 2583 1.5 feet.

- 2584 • April 10 to September 30: Compared to the No Action Alternative (262.5 and 264.0 feet
2585 NGVD29), the overall range and maximum elevation is increased by 2.5 feet.
- 2586 • November 15 to December 31: Compared to the No Action Alternative (262.0 and 266.5
2587 feet NGVD29), the minimum elevation is decreased by 0.5 foot, as is the overall operating
2588 range.

2589 The operating range for John Day Dam for Multi Objective Alternative 3 is shown in Figure 3-76.
2590 The No Action Alternative operating range is shown for comparison purposes.



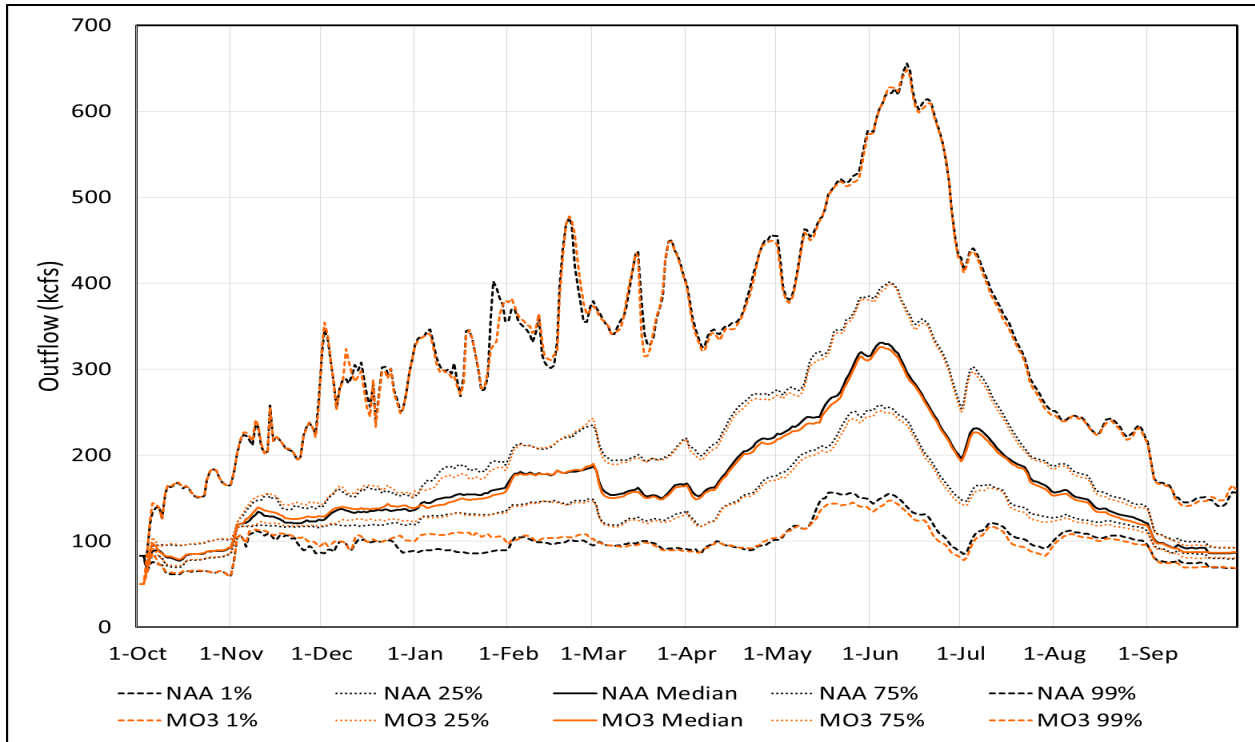
2591 **Figure 3-76. John Day Dam Operating Range for Multiple Objective Alternative 3**
2592 Note: John Day may be operated between 257 feet and 268 feet NGVD29 for FRM purposes. These limits are not
2593 shown on this figure in order to show greater detail in the vertical scale.
2594

2595 **Lower Columbia River Flows**

2596 Under MO3, the *Sliding Scale at Libby and Hungry Horse, Modified Draft at Libby, December*
2597 *Libby Target Elevation, Update System FRM Calculation, Planned Draft Rate at Grand Coulee,*
2598 *John Day Full Pool, Lake Roosevelt Additional Water Supply, Hungry Horse Additional Water*
2599 *Supply, and Chief Joseph Dam Project Additional Water Supply* measures would cause changes
2600 in flow patterns in the lower Columbia River.

2601 At McNary Dam, the outflows under MO3 would differ from the No Action Alternative to
2602 various extents through the water year. The magnitude and timing of differences in flow are
2603 displayed in the summary hydrograph, Figure 3-77.

2604 In addition to the daily outflow values depicted in Figure 3-77, the monthly average outflows
2605 from McNary Dam that would occur under MO3 were compared to those for the No Action
2606 Alternative, as shown in Table 3-37.



2607
2608 **Figure 3-77. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 3**

2609 Conclusions from this comparison are as follows:

- 2610 • In November and December, the median value of monthly average outflow would increase
2611 by 4.1 and 3.3 kcfs, respectively. There would be increases for most other exceedance
2612 values as well. The *December Libby Target Elevation* measure, which drafts Libby Dam to
2613 elevation 2,400 feet NGVD at the end of December for hydropower, is the main reason for
2614 these flow increases.
- 2615 • In January, the median value of the monthly average outflow would decrease by 4.5 kcfs.
2616 The degree to which flows would increase or decrease in January varies depending on the
2617 flow exceedance level.
- 2618 • In February, the median value of the monthly average outflow would increase by 0.7 kcfs.
2619 Again, the degree to which flows would increase or decrease depends on the flow
2620 exceedance level.
- 2621 • From March through October, monthly average outflow would generally be less than the No
2622 Action Alternative at all flow levels.

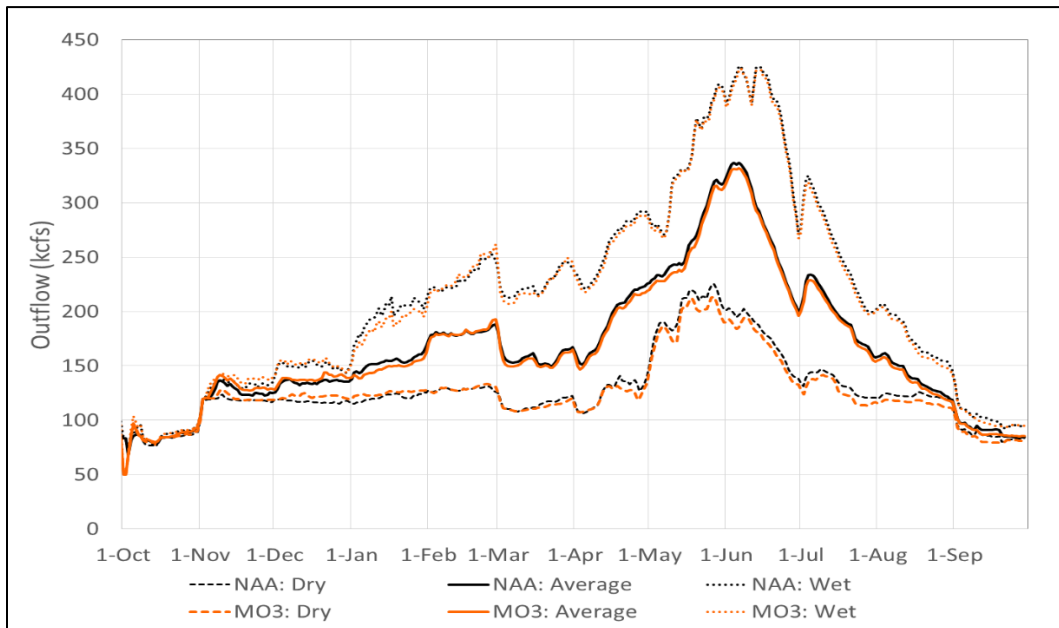
2623 Finally, median hydrographs for McNary Dam outflow in dry, average, and wet years are shown
2624 in Figure 3-78. MO3 and the No Action Alternative results are shown. The figure provides
2625 another way to picture the effects described above, this time categorized by water year type.
2626 For dry water years, it shows that flows in December and January would generally be higher,
2627 and flows from March through September would generally be lower.

2628 Along the lower Columbia River, the median value of the average monthly flow for MO3 would
2629 be higher than the No Action Alternative in some months (for example, November and
2630 December), and lower in others (for example, January and March through September). The flow
2631 change patterns seen at the confluence of the Columbia and Snake Rivers continue
2632 downstream to other locations. This is seen in Table 3-38.

2633 **Table 3-37. McNary Dam Monthly Average Outflow for Multiple Objective Alternative 3 (as**
2634 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcsfs)	1%	141	187	279	280	327	329	346	451	562	342	231	152
		25%	95	143	155	181	216	200	236	313	352	243	163	100
		50%	85	124	136	154	182	159	192	260	285	198	141	93
		75%	79	116	118	133	147	130	147	231	217	147	124	87
		99%	73	112	109	108	115	107	106	178	160	122	114	81
MO3	Change (kcsfs)	1%	-1.2	-1.7	-4.3	-0.4	3.3	0.4	-5.3	-4.1	-3.4	-5.2	-3.1	-1.6
		25%	-1.1	2.8	2.4	-10.3	1.2	-2.0	-5.8	-4.4	-5.7	-5.1	-4.4	-1.4
		50%	-1.1	4.1	3.3	-4.5	0.7	-2.6	-4.4	-6.9	-3.5	-3.7	-3.6	-1.8
		75%	-1.1	1.7	8.1	-1.7	-1.1	-2.0	-3.0	-6.4	-5.0	-4.6	-4.0	-1.5
		99%	-1.0	0.3	3.3	6.3	0.8	-1.0	-0.1	-10.0	-5.4	-6.3	-4.5	-2.0
	Percent change	1%	-1%	-1%	-2%	0%	1%	0%	-2%	-1%	-1%	-2%	-1%	-1%
		25%	-1%	2%	2%	-6%	1%	-1%	-2%	-1%	-2%	-2%	-3%	-1%
		50%	-1%	3%	2%	-3%	0%	-2%	-2%	-3%	-1%	-2%	-3%	-2%
		75%	-1%	2%	7%	-1%	-1%	-2%	-2%	-3%	-2%	-3%	-3%	-2%
		99%	-1%	0%	3%	6%	1%	-1%	0%	-6%	-3%	-5%	-4%	-2%

2635 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO3 flows lower than the No
2636 Action Alternative flows; green shading denotes MO3 flows higher than the No Action Alternative flows.



2637 **Figure 3-78. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective**
2638 **Alternative 3**
2639

2640 **Table 3-38. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 3**
2641 **(as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcfs)	Columbia+ Snake	83	122	134	151	181	157	188	260	288	199	140	91
	McNary	85	124	136	154	182	159	192	260	285	198	141	93
	John Day	85	125	140	156	185	165	198	267	288	197	141	93
	The Dalles	90	130	146	163	192	172	206	273	293	202	146	97
	Bonneville	91	135	152	170	199	179	213	275	296	204	149	99
	Columbia+ Willamette	108	178	225	252	267	233	260	314	319	216	159	111
	Columiba+ Cowlitz	115	196	257	282	295	255	283	334	336	226	165	117
Change (kcfs)	Columbia+ Snake	0.4	3.8	2.5	-4.6	0.6	-2.6	-4.7	-6.9	-4.7	-3.9	-3.4	-1.7
	McNary	-1.1	4.1	3.3	-4.5	0.7	-2.6	-4.4	-6.9	-3.5	-3.7	-3.6	-1.8
	John Day	-1.2	3.7	2.5	-4.9	0.9	-2.5	-4.5	-7.6	-3.4	-3.6	-3.9	-1.6
	The Dalles	-1.6	3.5	2.2	-5.3	0.7	-2.7	-4.1	-7.7	-3.3	-3.7	-4.0	-1.6
	Bonneville	0.2	3.6	2.3	-5.5	1.0	-3.1	-4.5	-7.0	-3.1	-3.7	-4.4	-1.7
	Columbia+ Willamette	-0.1	3.4	3.5	-4.2	0.1	-2.0	-4.3	-6.2	-3.1	-3.6	-4.5	-1.9
	Columiba+ Cowlitz	-0.3	3.8	4.5	-3.2	-0.5	-2.0	-4.2	-5.7	-3.8	-3.3	-3.9	-2.0
Percent Change	Columbia+ Snake	0%	3%	2%	-3%	0%	-2%	-2%	-3%	-2%	-2%	-2%	-2%
	McNary	-1%	3%	2%	-3%	0%	-2%	-2%	-3%	-1%	-2%	-3%	-2%
	John Day	-1%	3%	2%	-3%	0%	-2%	-2%	-3%	-1%	-2%	-3%	-2%
	The Dalles	-2%	3%	2%	-3%	0%	-2%	-2%	-3%	-1%	-2%	-3%	-2%
	Bonneville	0%	3%	2%	-3%	1%	-2%	-2%	-3%	-1%	-2%	-3%	-2%
	Columbia+ Willamette	0%	2%	2%	-2%	0%	-1%	-2%	-2%	-1%	-2%	-3%	-2%
	Columiba+ Cowlitz	0%	2%	2%	-1%	0%	-1%	-1%	-2%	-1%	-1%	-2%	-2%

2642 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO3 flows lower than the No
2643 Action Alternative flows; green shading denotes MO3 flows higher than the No Action Alternative flows.

2644 **SUMMARY OF EFFECTS**

2645 Under MO3, the largest changes in water levels occur at Libby, Grand Coulee, and the four
2646 lower Snake River dams. Lake Kocanusa water levels are substantially lower in most years
2647 from November through June, but can be higher in the drawdown period starting in January in
2648 larger forecast years, and reservoir levels are slightly higher in the later summer months. Lower
2649 Snake River dams are breached, and the four reservoirs in series are converted to a free-flowing
2650 river with water levels up to 80 feet lower and channel width up to 2,500 feet narrower.
2651 Smaller but notable water level changes occur at Hungry Horse Reservoir where additional
2652 water demands in the summer months result in slightly lower reservoir levels most of the year,
2653 and increased forebay operating flexibility at John Day Dam results in slightly higher typical and
2654 maximum water levels in April and May. Lake Roosevelt water levels are similar to the No
2655 Action Alternative in most years, and there are no changes at Dworshak Dam.

2656 The largest impacts to river flow occur immediately below Libby and Grand Coulee Dams, and
2657 total flow changes are largest below Grand Coulee Dam. November and December releases
2658 from Libby Dam are much higher, otherwise flows are lower, particularly in January and May.
2659 Outflow from Grand Coulee is lower in the spring and summer months due to additional
2660 pumping to Banks Lake. Changes in Lake Roosevelt inflow, notably higher November and

2661 December flows and lower January flows, stem from changes at Libby Dam and continue past
2662 Grand Coulee Dam downstream through the Columbia River. Changes in average monthly flow
2663 through the lower Columbia River are within 3 percent of the Not Action Alternative for all
2664 months for most years.

2665 **3.2.4.7 Multiple Objective Alternative 4**

2666 As the effects of MO4 are presented, they will be displayed along with the No Action
2667 Alternative to illuminate the timing and magnitude of differences in water conditions between
2668 it and the No Action Alternative. Similar to previous sections, the operational measure (or
2669 measures) from MO4 which would result in changes from the No Action Alternative are
2670 identified to the extent possible.

2671 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

2672 **Lake Koochanusa (Libby Dam Reservoir) Elevation**

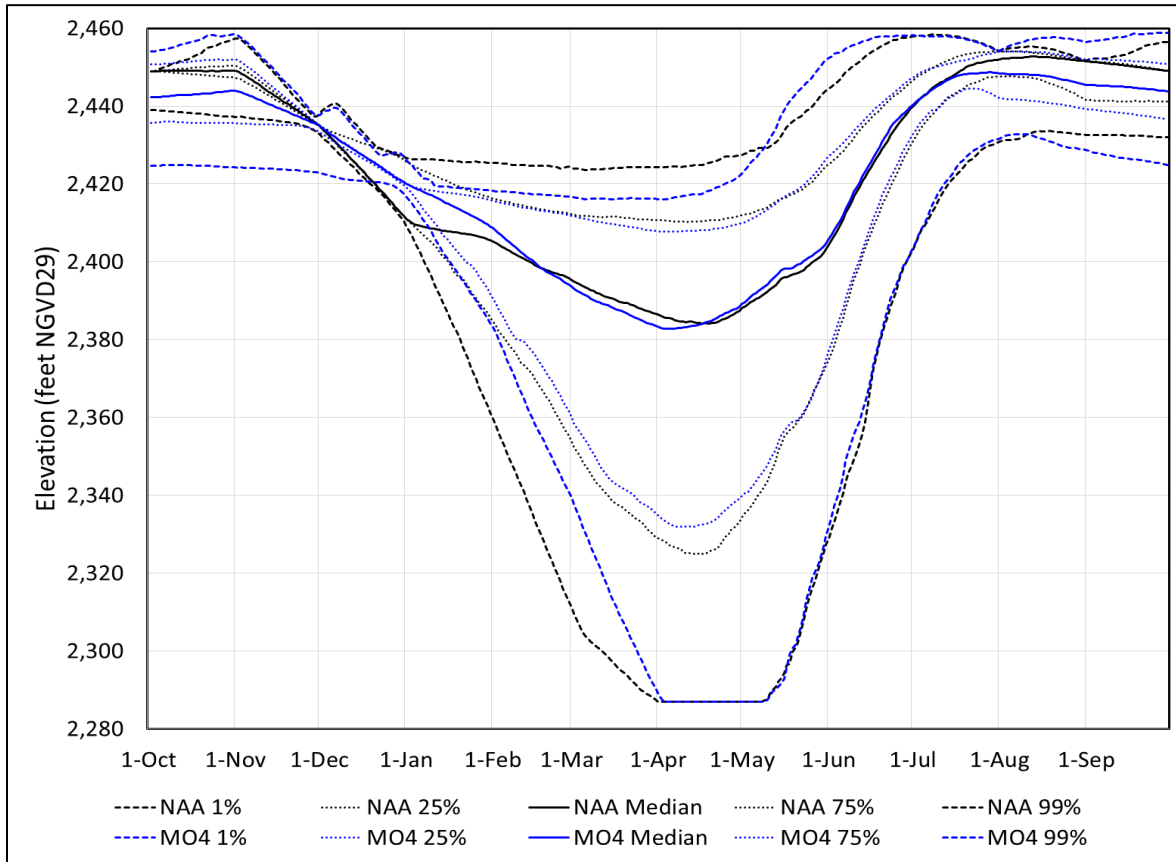
2673 Under MO4, the *McNary Flow Target*, *Sliding Scale at Libby and Hungry Horse*, *Modified Draft*
2674 *at Libby*, *December Libby Target Elevation*, and *Winter Stage for Riparian* measures would have
2675 a direct effect on Libby Dam operations.

2676 Reservoir water levels in Lake Koochanusa would differ from the No Action Alternative, as shown
2677 in the summary hydrograph, Figure 3-79.

2678 The water year would begin with the reservoir levels for MO4 being different (generally lower,
2679 but sometimes higher) than those for the No Action Alternative. This is because the operations
2680 that would occur from June through September under MO4 would leave the reservoir at a
2681 different elevation on September 30 than under the No Action Alternative, and the condition
2682 would carry over to the following water year. The *McNary Flow Target* measure, which aims to
2683 support higher flows at McNary Dam by releasing water stored at Libby Dam (as well as Hungry
2684 Horse, Albeni Falls, and Grand Coulee Dams) would release up to an additional 534 kaf of water
2685 from Libby Dam between May and the end of September in the years when it is triggered. The
2686 *Sliding Scale at Libby and Hungry Horse* measure, which calls for a sliding scale end-of-
2687 September target reservoir elevation dependent on the Libby Dam water supply forecast,
2688 targets a higher elevation than the No Action Alternative in the wettest 25 percent of years. The
2689 combined effect of the *McNary Flow Target* and *Sliding Scale at Libby and Hungry Horse*
2690 measures, then, would result in a wider range of reservoir elevations on October 1 than for the
2691 No Action Alternative. This is seen in Figure 3-79 with the range between the 99 percent
2692 exceedance line and the 1 percent exceedance line spanning from 2,425 to 2,454 feet NGVD29.

2693 MO4 would have the same end-of-November target reservoir elevation as the No Action
2694 Alternative. Over the course of December, the reservoir elevation under MO4 would differ from
2695 the No Action Alternative due to the *December Libby Target Elevation* measure, which calls for
2696 an end-of-December target elevation of 2,420 feet NGVD29 in all years. In most years, this
2697 would make the reservoir elevation on December 31 higher than the No Action Alternative;

2698 however, in about the driest 30 percent of forecast years (those forecasted to have an April to
 2699 August runoff volume of 5.67 Maf or less), the reservoir elevation on December 31 would be
 2700 lower than for the No Action Alternative.



2701
 2702 **Figure 3-79. Lake Koocanusa Summary Hydrograph for Multiple Objective Alternative 4**

2703 From December 31 through mid-February, reservoir levels would generally be higher under
 2704 MO4 than they would be for the No Action Alternative, though for the driest forecast years, the
 2705 reservoir would be lower.

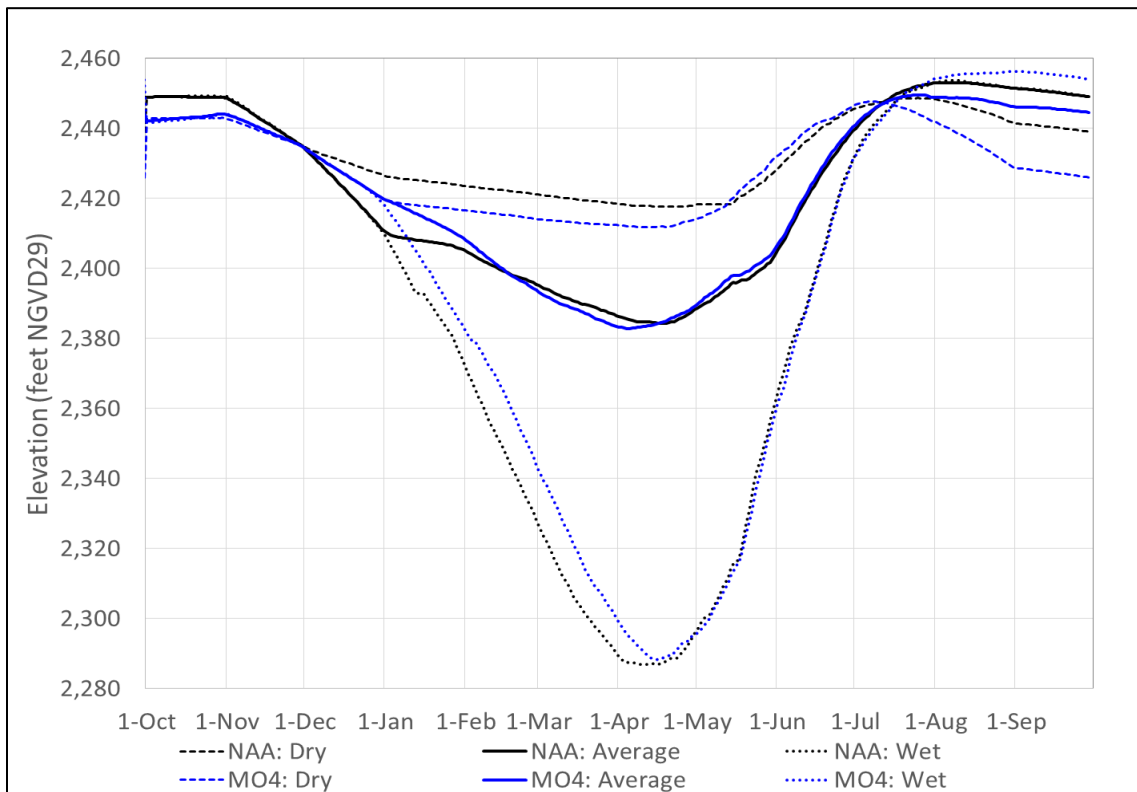
2706 The *Modified Draft at Libby* measure would begin influencing reservoir elevations after
 2707 December 31, and its effects are best understood by looking at the spring, when the lowest
 2708 reservoir elevation typically occurs. While the *Sliding Scale at Libby and Hungry Horse* measure
 2709 would generally delay the lowering of the reservoir, it is the *Modified Draft at Libby* measure
 2710 that would cause the spring reservoir elevation to be lower than the No Action Alternative
 2711 when the seasonal water supply forecast is less than 6.9 Maf at Libby Dam. This is not the case
 2712 for all years, though, as demonstrated by the 75 percent exceedance lines for MO4 and the No
 2713 Action Alternative. There, the case is the opposite; the reservoir elevation under MO4 would be
 2714 higher than that for the No Action Alternative through about the first half of spring.

2715 In years when the *Winter Stage for Riparian* measure would be in effect, it would have a direct
 2716 effect on Libby Dam operations at various times between the months of November and March.

2717 The modified releases would typically only occur for short durations of time while attempting to
 2718 limit water levels at Bonners Ferry. In these cases, there would be little noticeable effect on the
 2719 reservoir elevation at Libby Dam. In years when local flows are high, operations for the *Winter*
 2720 *Stage for Riparian* measure would last longer and result in slightly higher elevations in
 2721 November and December.

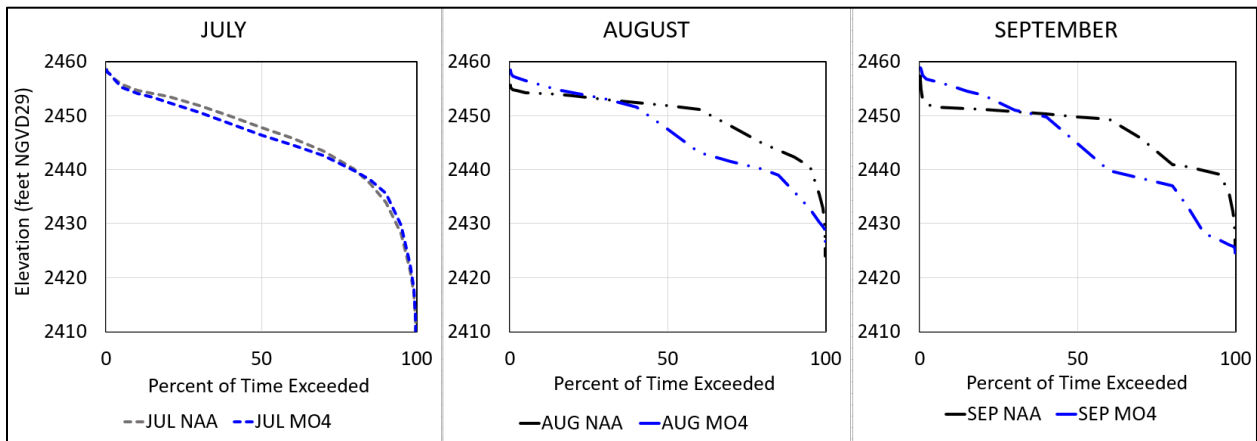
2722 The *Modified Draft at Libby* measure would result in a general increased likelihood of reservoir
 2723 refill in all water year types through June. In July, the refilling of the reservoir at Libby Dam
 2724 would be affected by the *McNary Flow Target* measure in the drier-than-normal years when the
 2725 *McNary Flow Target* measure is triggered, resulting in generally lower reservoir elevations in
 2726 July than for the No Action Alternative. In the years when the *McNary Flow Target* measure
 2727 would not be triggered, refilling of the reservoir would generally continue into July, similar to
 2728 the No Action Alternative. Overall, there would be a 36 percent chance of the reservoir
 2729 reaching elevation 2,454 feet NGVD29 or higher by July 31 under MO4, as compared to a 39
 2730 percent chance under the No Action Alternative. (The reservoir elevation of 2,454 feet NGVD is
 2731 often used when discussing reservoir refill, as it is within 5 feet of the full pool elevation of
 2732 2,459 feet NGVD29.)

2733 Reservoir water levels in Lake Kocanusa under MO4 would differ from the No Action
 2734 Alternative to varying extents, depending on the water year type. Median hydrographs of the
 2735 reservoir level for dry, average, and wet years are shown in Figure 3-80.



2736
 2737 **Figure 3-80. Lake Kocanusa Water Year Type Hydrographs for Multiple Objective Alternative**
 2738 **4**

2739 Finally, the three panels in Figure 3-81 show monthly elevation duration curves for July, August,
2740 and September, respectively. The curve for MO4 is plotted along with the curve for the No
2741 Action Alternative in each month. In July, reservoir elevations under MO4 would tend to be
2742 lower than the No Action Alternative by a slight amount. (It would be above elevation 2,446.5
2743 feet NGVD29 50 percent of the time for MO4, whereas it would be above elevation 2,447.9
2744 NGVD29 50 percent of the time for the No Action Alternative.) In August and September,
2745 reservoir elevations would usually be lower under MO4 than with the No Action Alternative due
2746 to the *McNary Flow Target* measure. However, about 30 percent of the time, it would be higher
2747 in those months under MO4, due to the absence of the *McNary Flow Target* measure being
2748 triggered while the *Sliding Scale at Libby and Hungry Horse* measure would continue to be in
2749 effect with an end-of-September target elevation.



2750
2751 **Figure 3-81. Lake Kocanusa Summer Elevations for Multiple Objective Alternative 4**

2752 **Libby Dam Outflow**

2753 Under MO4, the *McNary Flow Target*, *Sliding Scale at Libby and Hungry Horse*, *Modified Draft*
2754 *at Libby*, *December Libby Target Elevation*, and the *Winter Stage for Riparian* measures would
2755 have a direct effect on Libby Dam outflows. The outflows would differ from the No Action
2756 Alternative in a variety of ways throughout the year. Figure 3-82 shows median hydrographs for
2757 Libby Dam outflow in dry, average, and wet years.

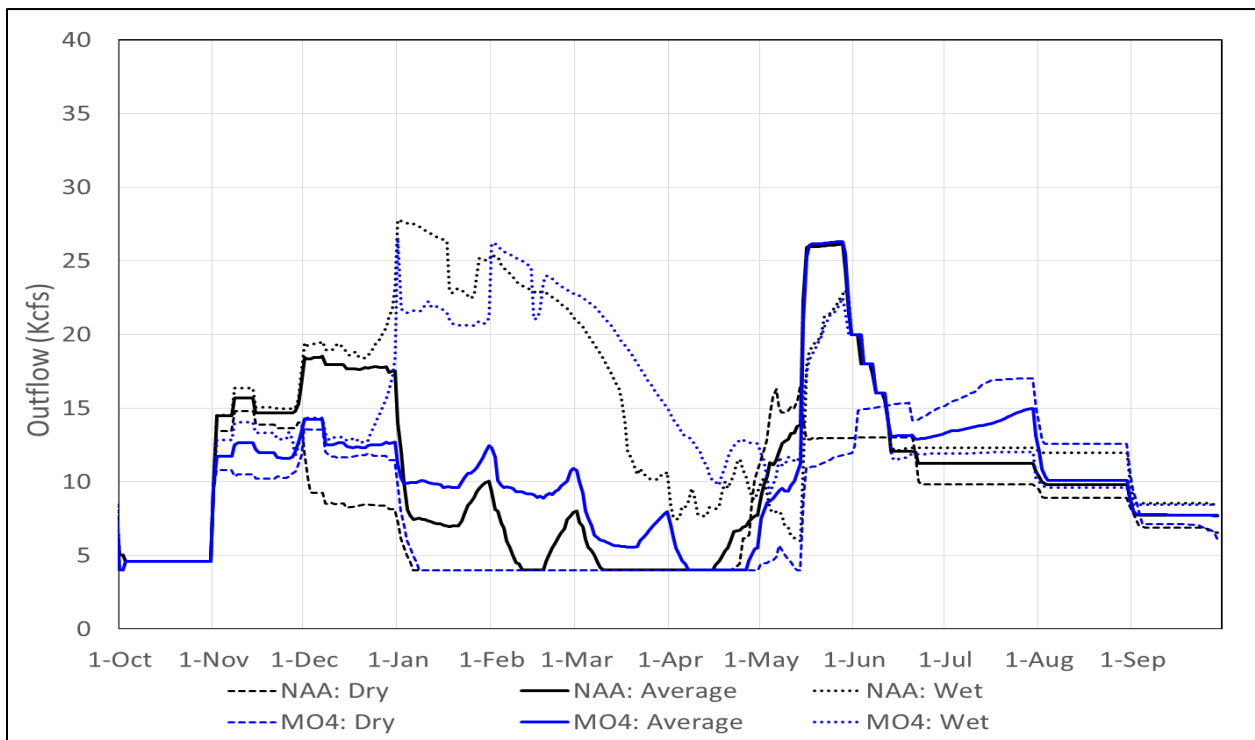
2758 The change in average monthly outflow throughout the water year is presented in Table 3-39.

2759 Average outflow from Libby Dam under MO4 would differ from the No Action Alternative:

- 2760 • In December, the median value of the monthly average outflow would decrease by 4.7 kcfs
2761 due to the *December Libby Target Elevation* measure. The flows at the 25 percent and 1
2762 percent exceedance levels (higher flows) would also decrease, while the flows at the 75
2763 percent exceedance level would increase.
- 2764 • In January, February and March the median value of the monthly average outflow would
2765 increase by 1.6, 3.3, and 1.6 kcfs, respectively. These outflow increases are caused by the
2766 reservoir being lowered at a faster rate under MO4 than the No Action Alternative for many

2767 years, caused by the *December Libby Target Elevation* measure as well as the *Modified Draft*
 2768 *at Libby* measure.

- 2769 • In April and May, the median value of the monthly average outflow would decrease by 1.4
 2770 and 0.8 kcfs, respectively. Both of these reductions are related to the VarQ update in the
 2771 *Modified Draft at Libby* measure that would account for future volume releases and refill
 2772 the reservoir more aggressively.
- 2773 • In June and July, the overall median value of the monthly average outflow would increase
 2774 by 0.6 and 2.9 kcfs, respectively. The increase in outflows occurs during dry and medium
 2775 years due primarily to the *McNary Flow Target* measure. The increasing shape of July
 2776 outflow stems from the HEC-ResSim model logic that adjusts Libby Reservoir draft targets to
 2777 meet the McNary Dam flow targets. If this measure was implemented, reservoir regulators
 2778 would strive to create smoother outflows in July and August by making the rise less
 2779 pronounced by spreading it out over a longer time.
- 2780 • In August median value of the monthly average outflow would increase by 0.2 kcfs, and in
 2781 September it would decrease by 0.1 kcfs.



2782
 2783 **Figure 3-82. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 2784 **Alternative 4**

2785 **Table 3-39. Libby Dam Monthly Average Outflow for Multiple Objective Alternative 4 (as**
2786 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	4.9	23.5	22.0	27.1	25.8	23.0	20.8	22.7	22.6	22.9	17.8	12.0
		25%	4.7	16.2	18.9	18.3	20.0	12.2	9.9	19.2	17.1	14.3	12.1	8.8
		50%	4.7	14.3	17.7	8.8	6.3	5.5	7.0	16.4	14.2	11.5	10.3	7.9
		75%	4.7	12.0	9.9	5.6	4.0	4.0	4.4	14.0	12.9	9.0	9.0	6.8
		99%	4.7	7.0	8.2	4.3	4.0	4.0	4.0	11.6	8.8	7.1	7.1	6.0
MO4	Change (kcfs)	1%	1.4	0.4	-2.4	-1.5	0.8	0.2	-2.2	0.1	1.6	1.5	-0.4	0.9
		25%	-0.1	0.4	-5.1	0.9	1.5	3.2	-1.4	-0.9	0.4	3.8	0.4	0.0
		50%	-0.1	-2.9	-4.7	1.6	3.3	1.6	-1.4	-0.8	0.6	2.9	0.2	-0.1
		75%	-0.1	-6.3	1.9	0.1	0.5	0.2	-0.1	-2.0	0.0	1.5	0.1	0.0
		99%	-0.1	-2.6	-1.1	0.3	0.0	0.0	0.0	-4.9	2.8	1.9	1.2	0.2
	Percent change	1%	28%	2%	-11%	-6%	3%	1%	-11%	0%	7%	7%	-2%	8%
		25%	-1%	3%	-27%	5%	7%	26%	-14%	-5%	2%	27%	4%	0%
		50%	-1%	-20%	-27%	18%	52%	29%	-21%	-5%	4%	25%	2%	-1%
		75%	-1%	-52%	19%	2%	12%	4%	-3%	-15%	0%	17%	1%	0%
		99%	-1%	-38%	-14%	7%	0%	0%	0%	-42%	32%	27%	17%	3%

2787 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO4 flows lower than the No
2788 Action Alternative flows; green shading denotes MO4 flows higher than the No Action Alternative flows.

2789 **Kootenai River below Libby Dam**

2790 Under MO4, the *McNary Flow Target, Sliding Scale at Libby and Hungry Horse, Modified Draft*
2791 *at Libby, December Libby Target Elevation, and Winter Stage for Riparian* measures would
2792 affect flows at Bonners Ferry. In general, the flows would differ from the No Action Alternative
2793 in much the same way as at Libby Dam, and for the same reasons. The change in average
2794 monthly flow at Bonners Ferry throughout the water year is presented in Table 3-40.

2795 The *Winter Stage for Riparian* measure in MO4 would change outflows from Libby Dam in a
2796 manner designed to aid survival of riparian vegetation along the Kootenai River. The measure
2797 would specifically try to limit river stages at Bonners Ferry to elevation 1,753 feet NGVD29 or
2798 below, between the months of November and March in certain years. The stage may exceed
2799 1,753 feet NGVD29 in years where the Libby Dam water supply forecast exceeds 6.9 Maf or
2800 local flows downstream of the dam cause the stage to exceed 1,753 feet NGVD29 while Libby
2801 Dam has reduced outflows to only 9 kcfs. Table 3-41 presents the change in median monthly
2802 river stage at various locations along an approximately 100-mile-long stretch of the Kootenai
2803 River, from RM 202 down to RM 103 at the U.S.-Canada border. The results presented are not
2804 solely the effect of the *Winter Stage for Riparian* measure. Rather, they represent the
2805 combined effect of five measures: the *McNary Flow Target, Sliding Scale at Libby and Hungry*
2806 *Horse, Modified Draft Rate at Libby, December Libby Target Elevation, and Winter Stage for*
2807 *Riparian* measures.

2808 **Table 3-40. Bonners Ferry Monthly Average Flow for Multiple Objective Alternative 4 (as**
2809 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	9.0	26.6	29.2	31.3	29.7	27.5	30.4	40.8	40.7	27.2	19.0	13.3
		25%	6.1	18.1	20.7	21.0	23.2	15.3	19.4	34.3	27.8	17.3	13.3	9.7
		50%	5.6	15.4	18.9	10.4	8.5	8.4	14.6	31.1	23.8	14.6	11.4	8.6
		75%	5.4	13.0	11.4	6.5	5.1	5.9	10.2	27.6	20.3	11.8	9.9	7.4
		99%	5.1	7.7	9.0	5.1	4.5	4.9	7.0	18.3	12.6	9.0	8.1	6.7
MO4	Change (kcfs)	1%	0.1	0.6	-2.3	-2.1	1.2	2.6	0.0	0.8	1.0	1.2	-0.8	1.6
		25%	-0.1	0.0	-5.1	0.1	0.4	3.8	-1.6	-0.3	0.2	3.6	0.4	0.0
		50%	-0.1	-2.2	-4.8	1.6	3.1	1.5	-0.9	-0.9	0.9	2.7	0.2	-0.1
		75%	-0.1	-5.7	1.3	0.3	0.6	0.5	-0.3	-3.6	0.8	2.0	0.4	0.1
		99%	-0.1	-2.6	-0.9	0.3	0.1	0.0	0.0	-4.4	2.7	2.4	0.9	0.1
	Percent change	1%	1%	2%	-8%	-7%	4%	10%	0%	2%	2%	4%	-4%	12%
		25%	-1%	0%	-25%	1%	2%	25%	-8%	-1%	1%	21%	3%	0%
		50%	-1%	-14%	-25%	16%	36%	18%	-6%	-3%	4%	19%	1%	-1%
		75%	-1%	-44%	12%	5%	12%	9%	-3%	-13%	4%	17%	4%	1%
		99%	-2%	-34%	-10%	5%	2%	0%	0%	-24%	21%	26%	11%	1%

2810 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO4 flows lower than the No
2811 Action Alternative flows; green shading denotes MO4 flows higher than the No Action Alternative flows.

2812 **Table 3-41. Kootenai River stage for Multiple Objective Alternative 4 (as change from No**
2813 **Action Alternative)**

Kootenai River Location	Changes in Median Monthly River Stage (feet)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
RM 202	0.0	-1.2	-1.4	0.4	1.3	1.1	-0.3	-0.8	0.3	0.8	0.1	0.0
RM 169	0.0	-1.1	-1.5	0.3	1.1	0.7	-0.2	-0.9	0.3	0.9	0.1	0.0
RM 150 (Bonners Ferry)	0.0	-0.9	-1.3	0.4	1.2	0.8	-0.3	-1.0	0.0	1.3	0.1	0.0
RM 140	0.0	-0.6	-1.0	0.3	0.8	0.6	-0.3	-1.0	-0.1	1.2	0.1	0.0
RM 103 (US-Can Border)	0.0	-0.3	-0.4	0.1	0.2	0.3	-0.1	-0.6	-0.1	0.7	0.0	0.0

2814 Note: Orange shading denotes MO4 stages lower than the No Action Alternative stages; green shading denotes
2815 MO4 stages higher than the No Action Alternative stages.

2816 The decrease in median monthly outflow from Libby Dam in November and December translate
2817 to decreases in water levels of just over a foot in the free-flowing reach below Libby Dam. At
2818 Bonners Ferry, the decreases in median average monthly outflow for November and December
2819 are 0.9 foot and 1.3 feet. Below Bonners Ferry, the decrease in stage is smaller but is still a few
2820 tenths of a foot at RM 103 near the U.S.-Canada border.

2821 While the above table presents general information on when river stages would tend to be
2822 higher or lower throughout the year, it does not show the extent to which river stages would be
2823 above elevation 1,753 feet NGVD29 from November through March. That information is
2824 presented in Table 3-42.

2825 **Table 3-42. Percentage of Days Kootenai River Stage Would be Above 1,753 feet NGVD29 at**
2826 **the Bonners Ferry Gage**

	November	December	January	February	March
NAA	10.0%	12.8%	20.7%	17.9%	5.4%
MO4	9.9%	4.4%	14.9%	20.5%	8.0%
Change	-0.1%	-8.4%	-5.8%	2.6%	2.6%

2827 Note: Results reflect modeling of all years, not just those when the *Winter Stage for Riparian* measure would be in
2828 effect.

2829 Under MO4, the months of December and January would have fewer days exceeding elevation
2830 1,753 feet NGVD29, while February and March would have more days exceeding that stage.
2831 Considering the entire 5-month period from November through March, there would be an
2832 overall decrease in days where the river stage would be above elevation 1,753 feet NGVD29.
2833 Further discussion of the effects from this measure are contained in Section 3.6.3, which covers
2834 environmental consequences to vegetation, wetland, and wildlife resources. It is worth noting
2835 that the *Winter Stage for Riparian* measure would not be in effect for years when the water
2836 supply forecast at Libby Dam is greater than 6.9 Maf.

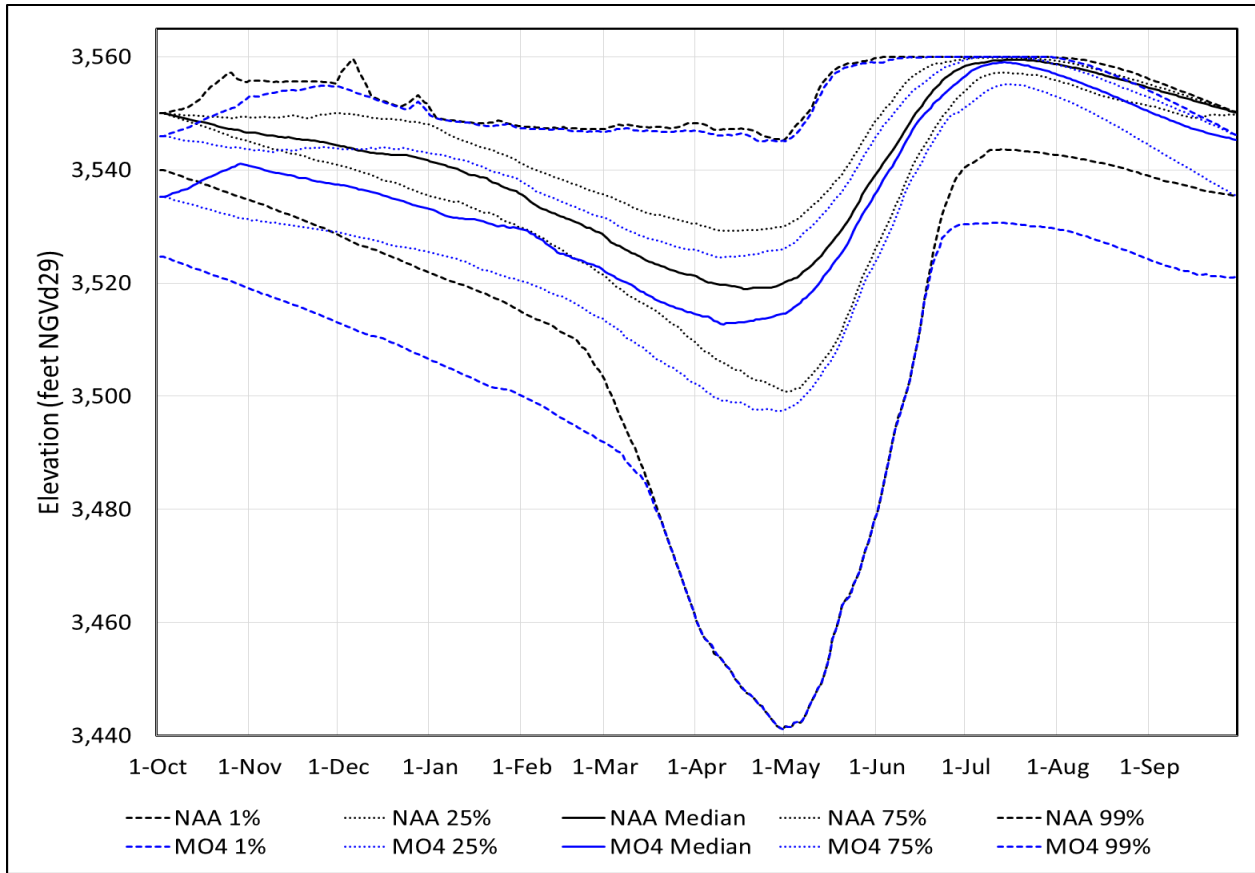
2837 **Hungry Horse Reservoir Elevation**

2838 Under MO4, the *McNary Flow Target*, *Sliding Scale at Libby and Hungry Horse*, and *Hungry*
2839 *Horse Additional Water Supply* measures would have a direct effect on Hungry Horse Dam
2840 operations.

2841 Reservoir water levels would differ from the No Action Alternative, as shown in Figure 3-83.

2842 The water year would begin with the reservoir levels for MO4 being lower than those for the
2843 No Action Alternative. This is because the operations associated with the *McNary Flow Target*
2844 and *Hungry Horse Additional Water Supply* measures would leave the reservoir at a lower
2845 elevation on September 30 than under the No Action Alternative, and the condition would carry
2846 over to the following water year.

2847 The *McNary Flow Target* measure would release up to 232 kaf of water from Hungry Horse
2848 Dam in the years when it is triggered, the *Hungry Horse Additional Water Supply* measure
2849 would draft up to 90 kaf of stored water, and the *Sliding Scale at Libby and Hungry Horse*
2850 measure would generally tend to lessen the summer draft. The *Sliding Scale at Libby and*
2851 *Hungry Horse* measure results in reducing the draft requirements in some years, by setting a
2852 higher elevation target for summer flow augmentation than the No Action Alternative.
2853 However, its combination with the other measures would result in lower summer elevations.
2854 The overall effect, then, would be a lower reservoir elevation on October 1 than for the No
2855 Action Alternative. This is seen in Figure 3-83 with the range between the 99 percent
2856 exceedance line and the 1 percent exceedance line spanning from 3,525 feet NGVD29 to 3,546
2857 feet NGVD29.



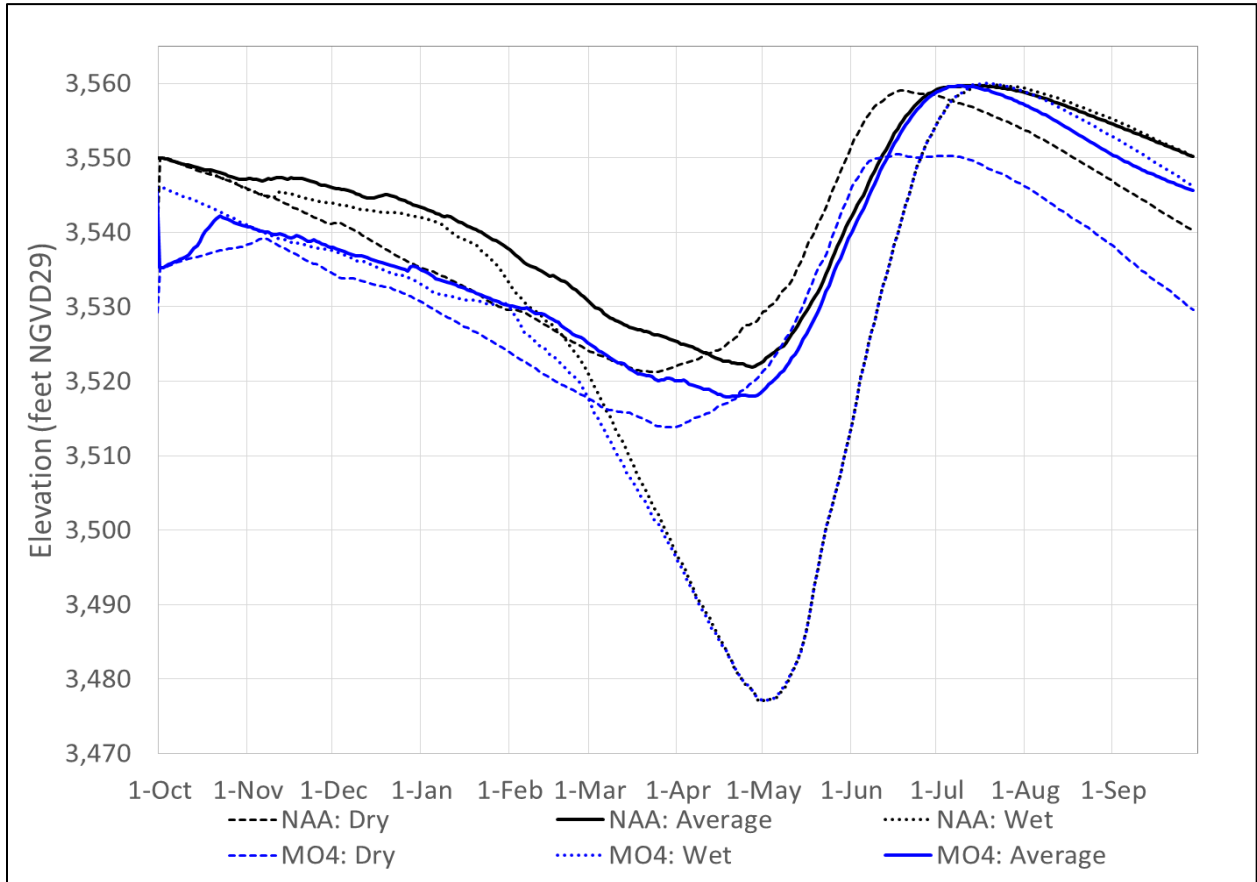
2858
 2859 **Figure 3-83. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative**
 2860 **4**

2861 Reservoir elevations under MO4 would be lower than for the No Action Alternative. The
 2862 greatest difference would occur in the months of September through April (about 5 to 9 feet
 2863 difference) and the least difference would occur in May through August (about 2 to 4 feet
 2864 difference). The most pronounced differences in reservoir elevation between MO4 and the No
 2865 Action Alternative would occur when one dry water year is followed by another dry water year.
 2866 In these instances, reservoir levels under MO4 could be more than 15 feet lower than for the
 2867 No Action Alternative.

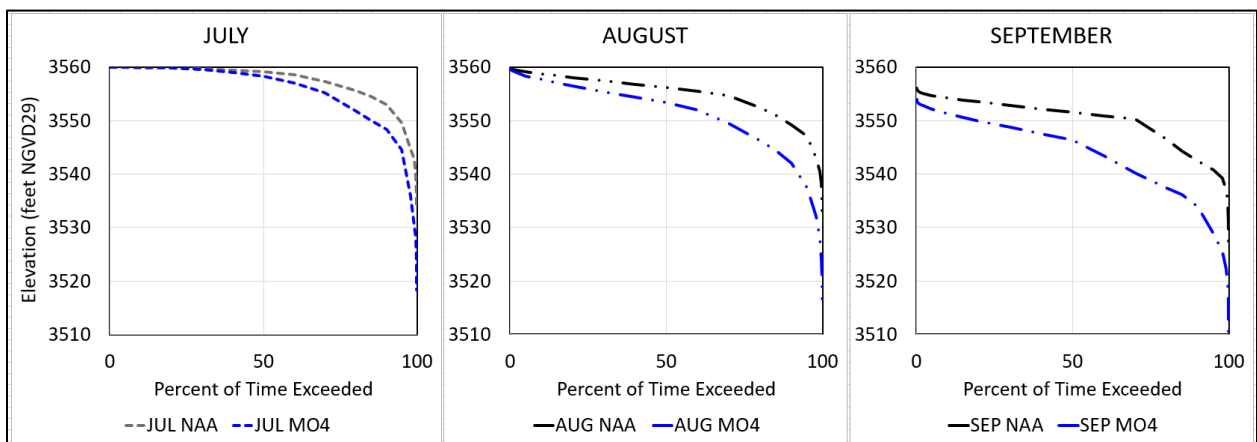
2868 Water levels at Hungry Horse Reservoir under MO4 would differ from the No Action Alternative
 2869 to varying extents, depending on the water year type. Median hydrographs of the reservoir
 2870 level for dry, average, and wet years are shown in Figure 3-84.

2871 Finally, the three panels in Figure 3-85 show Hungry Horse Reservoir elevation duration curves
 2872 for the months of July, August, and September, respectively. While other months also have
 2873 differences, these three are shown because of interest in summer reservoir elevations, and due
 2874 to carryover impacts on winter elevation and spring flows. In general, the reservoir level in the
 2875 summer months would be lower for MO4 than for the No Action Alternative. For instance, the
 2876 daily reservoir elevation in September would be above elevation 3,550 feet NGVD29 only about

2877 20 percent of the time under MO4, whereas it would be above that elevation about 70 percent
 2878 of the time under the No Action Alternative.



2879
 2880 **Figure 3-84. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective**
 2881 **Alternative 4**



2882
 2883 **Figure 3-85. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 4**

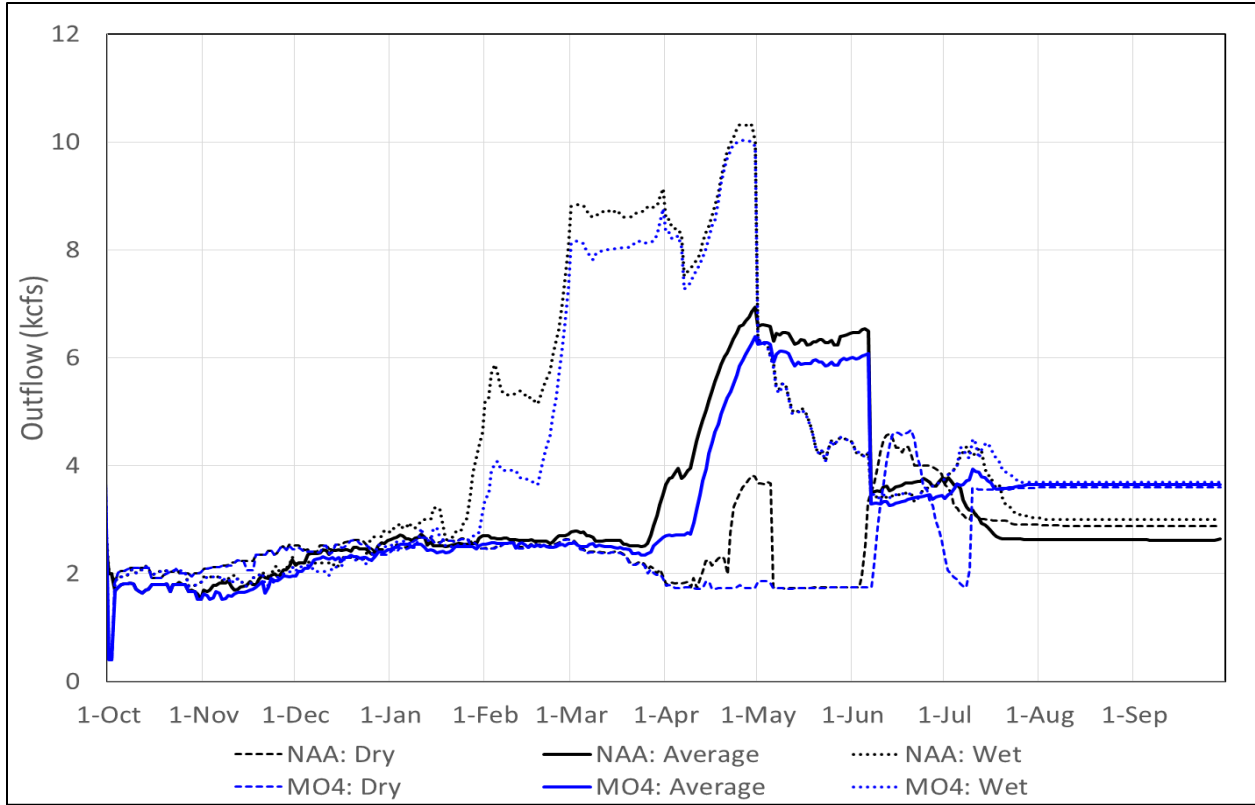
2884 **Hungry Horse Dam Outflow**

2885 Under MO4, the *McNary Flow Target*, *Sliding Scale at Libby and Hungry Horse*, and *Hungry*
2886 *Horse Additional Water Supply* measures would have a direct effect on Hungry Horse Dam
2887 outflows. The outflows would differ from the No Action Alternative depending on the time of
2888 year. Figure 3-86 shows median hydrographs for Hungry Horse Dam outflow in dry, average,
2889 and wet years.

2890 The change in average monthly outflow from Hungry Horse Dam throughout the water year is
2891 presented in Table 3-43.

2892 Average outflow from Hungry Horse Dam would differ from the No Action Alternative:

- 2893 • In July, August, and September the median value of the monthly average outflow would
2894 increase by 0.4, 1.0, and 1.0 kcfs, respectively, as compared to the No Action Alternative.
2895 The measures driving these changes are the *McNary Flow Target* and *Hungry Horse*
2896 *Additional Water Supply* measures. While the *Sliding Scale at Libby and Hungry Horse*
2897 measure would have a minor influence on flows in August and September (in isolation, it
2898 would tend to slightly reduce outflows), the overall effect of MO4 is to increase outflows in
2899 the summer. (The table above shows August and September flows 23 percent to 37 percent
2900 greater than the No Action Alternative.)
- 2901 • After September and through the spring, reservoir outflows would generally be lower than
2902 for the No Action Alternative. This is because the reservoir would be in a deeply drafted
2903 state at the end of September. Outflows would either be supporting minimum flows in the
2904 Flathead River system (the same being true of the No Action Alternative), or they would be
2905 reduced in an attempt to fill back to normal winter elevations when minimum flows are
2906 already being met. The decrease in the median monthly average outflow would range from
2907 0.1 kcfs to 0.8 kcfs during the October through April timeframe.
- 2908 • May and June would continue to show a reduction in outflow. The median value of the
2909 monthly average outflow would decrease by 0.3 and 0.2 kcfs, respectively.



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Figure 3-86. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4

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Table 3-43. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 4 (as change from No Action Alternative)

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	2.5	4.7	6.9	7.1	11.5	14.5	15.6	9.6	10.7	6.9	4.4	4.4
		25%	2.2	2.4	2.7	3.1	4.0	5.7	8.1	7.0	6.1	4.2	3.1	3.1
		50%	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7
		75%	1.4	1.4	2.1	2.3	2.4	2.2	3.1	4.1	3.2	2.6	2.4	2.4
		99%	0.8	0.8	1.6	2.0	1.7	1.5	1.7	1.7	1.7	1.7	1.8	1.9
MO4	Change (kcfs)	1%	-0.1	-0.7	-2.3	-0.8	-0.2	-0.3	-0.2	-0.1	-0.3	0.0	1.0	1.0
		25%	-0.1	0.0	-0.1	-0.4	-0.9	-0.8	-0.4	-0.3	-0.2	0.3	1.1	1.1
		50%	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.8	-0.3	-0.2	0.4	1.0	1.0
		75%	-0.1	-0.2	-0.3	-0.2	-0.1	-0.1	-0.6	-0.3	-0.2	0.4	0.8	0.8
		99%	-0.3	-0.2	-0.5	-0.4	-0.1	0.0	0.0	0.0	0.0	0.4	0.5	0.6
	Percent change	1%	-2%	-16%	-34%	-11%	-2%	-2%	-2%	-1%	-3%	0%	23%	23%
		25%	-4%	-1%	-5%	-12%	-22%	-14%	-5%	-4%	-3%	8%	36%	36%
		50%	-6%	-6%	-6%	-3%	-4%	-7%	-15%	-6%	-5%	11%	37%	37%
		75%	-10%	-14%	-12%	-7%	-5%	-4%	-18%	-8%	-6%	17%	35%	35%
		99%	-37%	-29%	-32%	-18%	-5%	-3%	-3%	-1%	-2%	23%	28%	28%

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Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO4 flows lower than the No Action Alternative flows; green shading denotes MO4 flows higher than the No Action Alternative flows.

2917 **Columbia Falls Flow**

2918 Under MO4, the *McNary Flow Target, Sliding Scale at Libby and Hungry Horse*, and *Hungry*
 2919 *Horse Additional Water Supply* measures would affect flows at Columbia Falls. Compared to the
 2920 No Action Alternative, there would be increased flow in July, August, and September in virtually
 2921 all years, while the other months of the year would generally have flows less than those under
 2922 the No Action Alternative, while still meeting minimum flow requirements. The change in
 2923 average monthly flow at Columbia Falls throughout the water year, as compared to the No
 2924 Action Alternative, is presented in Table 3-44.

2925 **Table 3-44. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 4 (as**
 2926 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	8.9	14.4	14.8	11.0	14.2	17.4	30.5	38.0	43.2	23.9	8.8	8.7
		25%	4.0	4.2	4.5	5.0	5.8	7.9	15.9	29.7	31.5	15.1	6.9	5.4
		50%	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7
		75%	3.6	3.6	3.6	3.6	3.6	3.7	8.5	21.4	20.0	8.4	4.9	4.2
		99%	3.5	3.5	3.5	3.5	3.5	3.5	5.4	15.7	12.4	5.5	3.9	3.6
MO4	Change (kcfs)	1%	-1.7	-2.3	-3.4	-1.2	-0.2	-0.5	-0.4	-0.2	0.0	-0.1	0.8	0.8
		25%	-0.1	0.0	-0.6	-0.8	-1.0	-0.7	-0.6	-0.4	-0.2	0.2	0.9	1.0
		50%	-0.1	0.0	0.0	-0.1	-0.1	-0.4	-0.7	-0.2	-0.1	0.5	0.9	1.0
		75%	-0.1	0.0	0.0	0.0	0.0	0.0	-0.6	-0.4	-0.1	0.5	1.0	0.8
		99%	-0.1	0.0	0.0	0.0	0.0	0.0	-0.4	-0.3	-0.1	0.4	0.5	0.5
	Percent change	1%	-19%	-16%	-23%	-11%	-2%	-3%	-1%	-1%	0%	0%	9%	9%
		25%	-3%	-1%	-14%	-16%	-17%	-8%	-4%	-1%	-1%	2%	14%	19%
		50%	-3%	-1%	0%	-2%	-2%	-9%	-6%	-1%	0%	4%	16%	22%
		75%	-2%	0%	0%	0%	0%	-1%	-7%	-2%	-1%	5%	20%	19%
		99%	-3%	0%	0%	0%	0%	0%	-8%	-2%	-1%	7%	13%	14%

2927 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO4 flows lower than the No
 2928 Action Alternative flows; green shading denotes MO4 flows higher than the No Action Alternative flows.

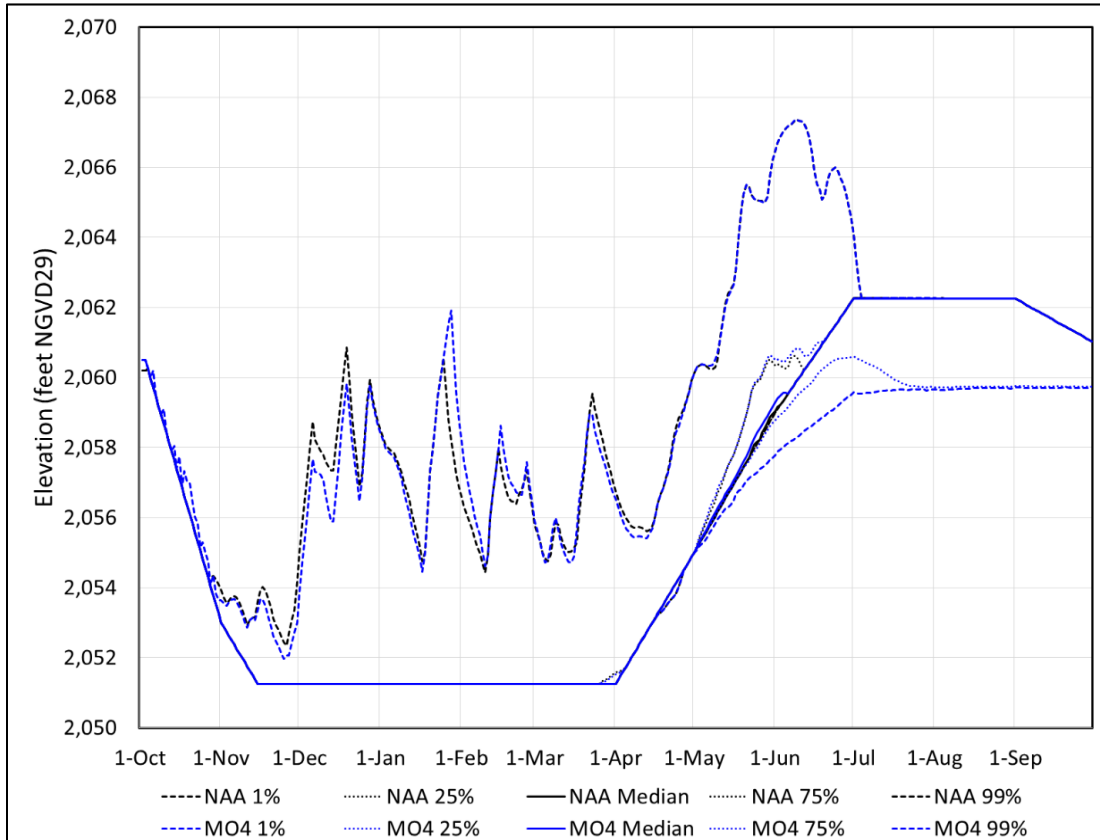
2929 **Lake Pend Oreille Elevation**

2930 Under MO4, the *McNary Flow Target* measure would have a direct effect on the level of Lake
 2931 Pend Oreille. Lake levels would differ from the No Action Alternative during the months of May
 2932 through September in years with drier-than-normal conditions. This is shown in Figure 3-87.

2933 The *McNary Flow Target* measure, which aims to support higher flows at McNary Dam by
 2934 releasing water stored at Albeni Falls Dam (as well as Libby, Hungry Horse, and Grand Coulee
 2935 Dams) would release up to 234 kaf of water from Lake Pend Oreille in years when the measure
 2936 is triggered. A release of 234 kaf corresponds to a reduction in water level at Lake Pend Oreille
 2937 of approximately 2.6 feet below the typical summer elevation. In the years when the *McNary*
 2938 *Flow Target* measure is not triggered, there would not be any noticeable difference in the level
 2939 of Lake Pend Oreille as compared to the No Action Alternative.

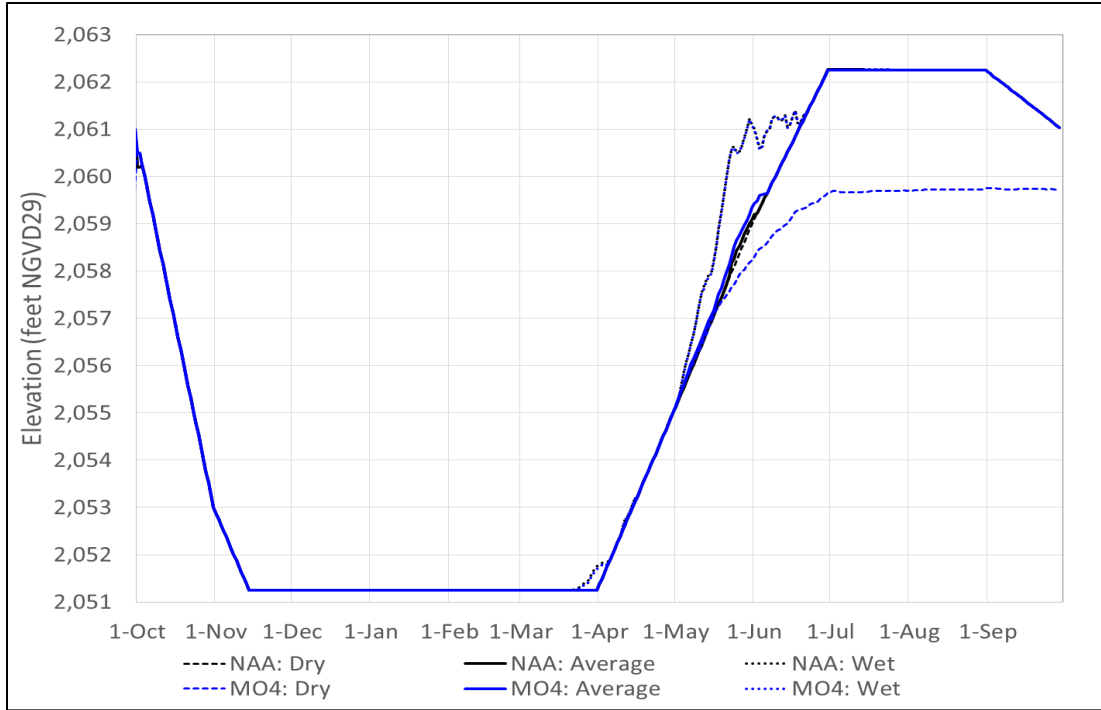
2940 The lower lake levels that would result from the *McNary Flow Target* measure are reflected in
 2941 the 99 percent and 75 percent exceedance lines for MO4 beginning in May (99 percent
 2942 exceedance level) and beginning in June (75 percent exceedance level).

2943 Figure 3-88 demonstrates the timing and magnitude of how the level of Lake Pend Oreille
 2944 would change under MO4. The figure shows median hydrographs for the lake level in dry,
 2945 average, and wet years. As expected, the summer lake levels in dry years would be lower than
 2946 they would be for the No Action Alternative.



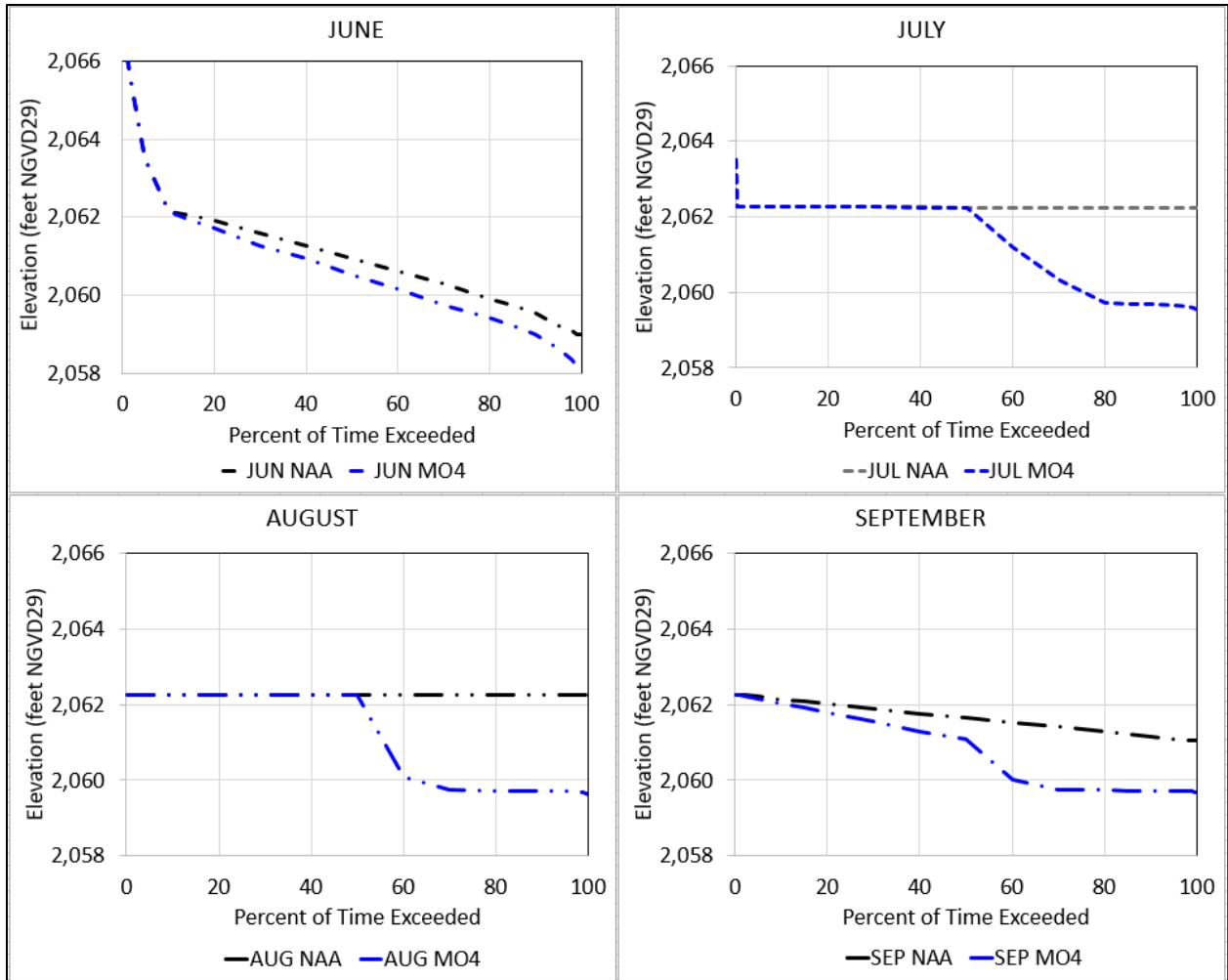
2947
 2948 **Figure 3-87. Lake Pend Oreille Summary Hydrograph for Multiple Objective Alternative 4**

2949 Finally, elevation duration curves are useful for understanding how lake levels under MO4
 2950 would differ from the No Action Alternative. The four panels in Figure 3-89 show monthly
 2951 elevation duration curves for June, July, August, and September, respectively. Looking at the
 2952 July and August panels, it is seen that under MO4, the lake level would be lower than the No
 2953 Action Alternative about half of the time, when the *McNary Flow Target* measure is triggered.
 2954 The expectation for summer lake levels to be lower than the No Action Alternative about half
 2955 the time, is an important point that is not otherwise seen in either the summary hydrograph
 2956 (Figure 3-87) or the median hydrographs (Figure 3-88) for dry/average/wet years.



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 2959

Figure 3-88. Lake Pend Oreille Water Year Type Hydrographs for Multiple Objective Alternative 4



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Figure 3-89. Lake Pend Oreille Summer Elevations for Multiple Objective Alternative 4

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Note: The typical summer elevation range for Lake Pend Oreille in the No Action Alternative is 2,062.0 to 2,062.5 feet NVGD29. It is represented as 2,062.25 feet NGVD29 in the HEC-ResSim model, so appears as 2,062.25 feet NGVD29 in the panels above.

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Albeni Falls Outflow

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Under MO4, the *McNary Flow Target* measure would directly affect Albeni Falls Dam outflow.

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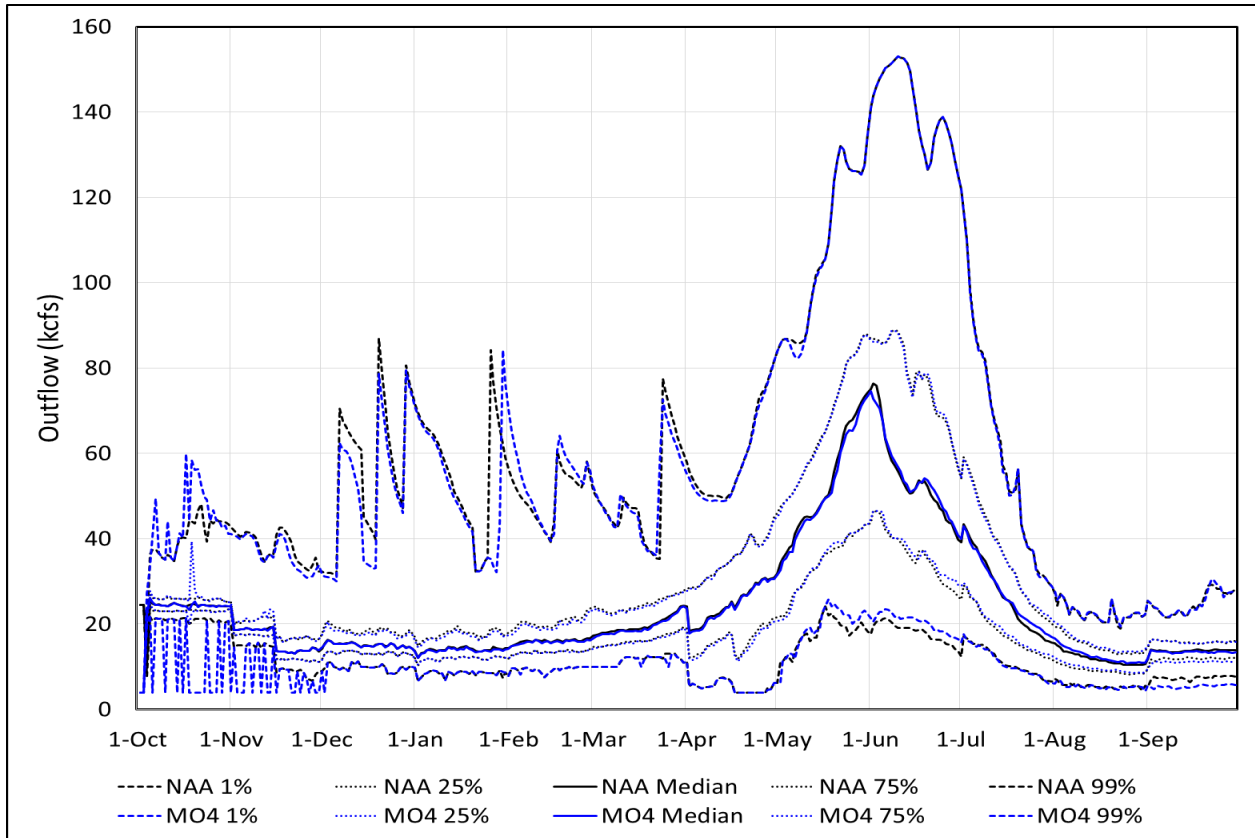
An indirect influence would come from the *Sliding Scale at Libby and Hungry Horse* and the

2968

Hungry Horse Additional Water Supply measures. The outflows would differ from the No Action

2969

Alternative as seen in Figure 3-90.



2970
2971 **Figure 3-90. Albeni Falls Dam Outflow Summary Hydrograph for Multiple Objective**
2972 **Alternative 4**
2973 Note: The 99 percent exceedance values depicted for October/November are a modeling artifact related to ResSim
2974 model setup.

2975 The *McNary Flow Target* measure is the main driver for the June through September outflows
2976 that would differ from the No Action Alternative. From September through May, the median
2977 value of the monthly average outflow from Albeni Falls Dam under MO4 would be the same or
2978 slightly lower than that for the No Action Alternative due to operational changes at Hungry
2979 Horse Dam; in June, July, and August it would be greater. This is shown in Table 3-45, which also
2980 includes the changes that would occur at upstream locations.

2981 Under MO4, monthly average outflows from Albeni Falls Dam would differ from the No Action
2982 Alternative:

- 2983 • In June, July, and August, the median value of the monthly average outflow would be
2984 greater than the No Action Alternative by 0.4, 0.6, and 0.7 kcfs, respectively. The *McNary*
2985 *Flow Target* measure is the primary cause of these changes.
- 2986 • In September, the median value of the monthly average outflow would be lower than the
2987 No Action Alternative by 0.5 kcfs. The *McNary Flow Target* measure is the primary cause of
2988 this change.

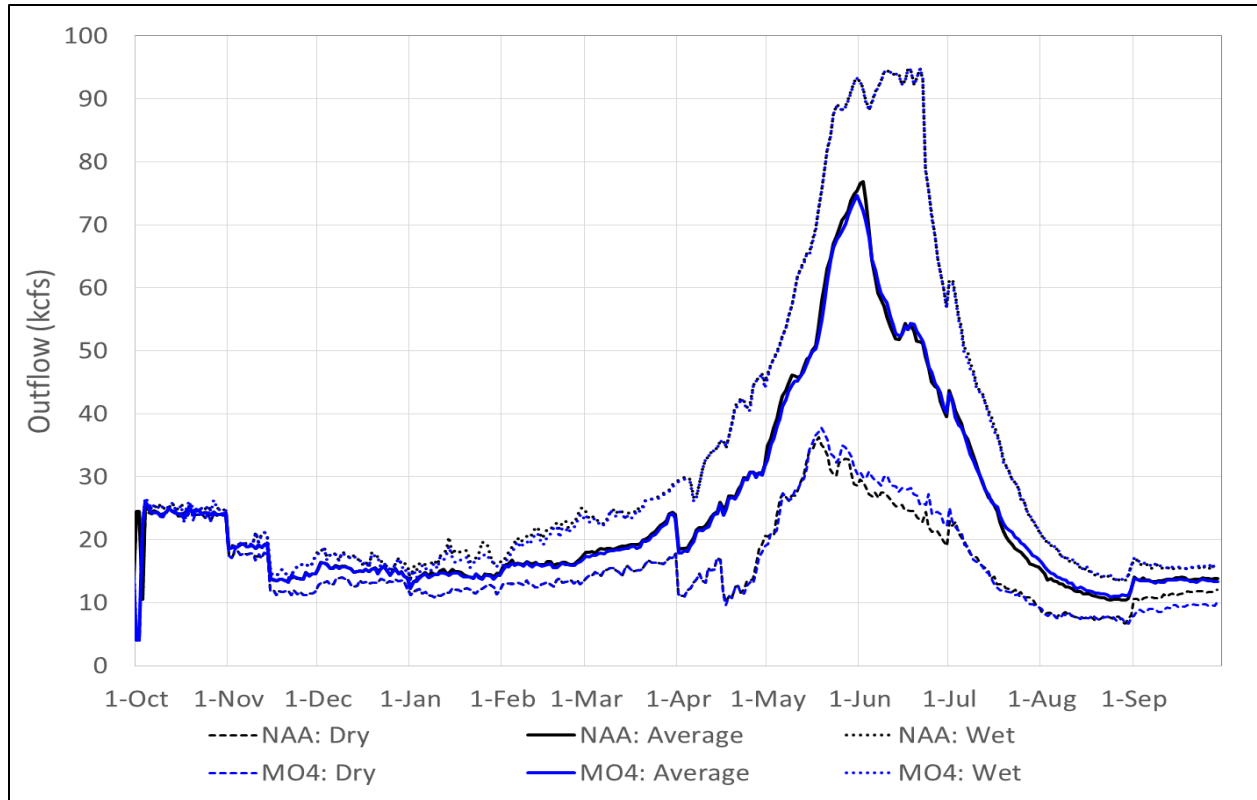
2989 The results in Table 3-45 are based on median values of monthly average flows, so by
2990 definition, they do not separate out years when the *McNary Flow Target* measure is triggered
2991 from those when it is not triggered. Rather, they represent the overall trend considering all
2992 years lumped together.

2993 The median outflow hydrographs shown in Figure 3-91 are useful for understanding how the
2994 Albeni Falls outflow under MO4 would differ from the No Action Alternative in different types
2995 of years. Most notably, the outflow from Albeni Falls Dam under MO4 would be greater than
2996 that for the No Action Alternative in dry years, due to the *McNary Flow Target* measure. In the
2997 dry years, the late spring flows would be higher than for the No Action Alternative. Continuing
2998 through the summer, outflows would also be higher in July and August, as seen in the median
2999 hydrograph for average years.

3000 **Table 3-45. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 4 (as**
3001 **change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcs)	Hungry Horse	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7
	Columbia Falls, MT	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7
	Albeni Falls	23.7	16.7	15.3	14.5	16.6	19.8	25.2	50.7	55.6	27.4	12.0	13.7
Change (kcs)	Hungry Horse	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.8	-0.3	-0.2	0.4	1.0	1.0
	Columbia Falls, MT	-0.1	0.0	0.0	-0.1	-0.1	-0.4	-0.7	-0.2	-0.1	0.5	0.9	1.0
	Albeni Falls	-0.9	-0.1	0.0	-0.1	-0.4	-0.2	-0.7	-0.5	0.4	0.6	0.7	-0.5
Percent Change	Hungry Horse	-6%	-6%	-6%	-3%	-4%	-7%	-15%	-6%	-5%	11%	37%	37%
	Columbia Falls, MT	-3%	-1%	0%	-2%	-2%	-9%	-6%	-1%	0%	4%	16%	22%
	Albeni Falls	-4%	-1%	0%	-1%	-3%	-1%	-3%	-1%	1%	2%	5%	-4%

3002 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO4 flows lower than the No
3003 Action Alternative flows; green shading denotes MO4 flows higher than the No Action Alternative flows.



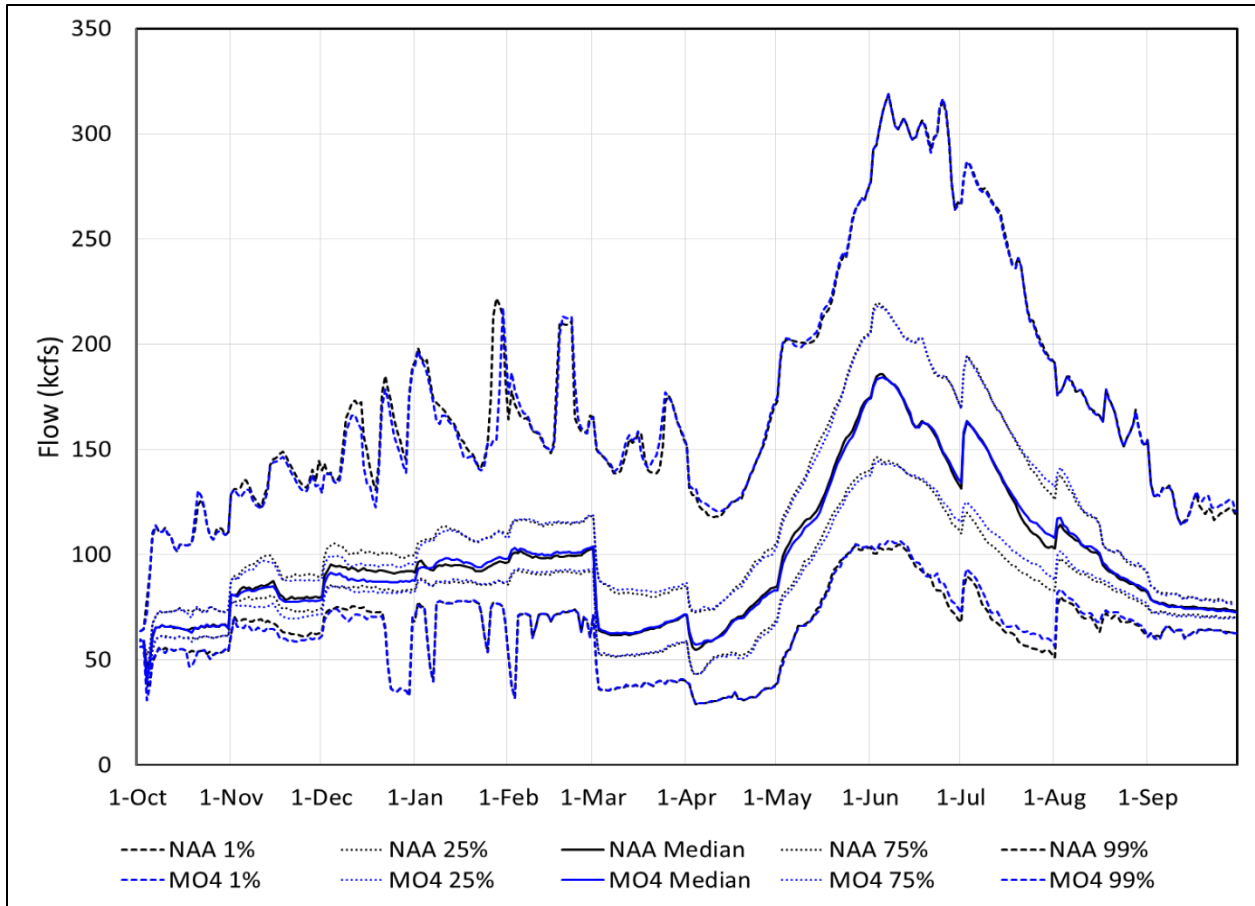
3004
 3005 **Figure 3-91. Albeni Falls Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 3006 **Alternative 4**

3007 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

3008 **Columbia River flow upstream of Grand Coulee Dam**

3009 Under MO4, the *McNary Flow Target*, *Sliding Scale at Libby and Hungry Horse*, *Modified Draft*
 3010 *at Libby*, *December Libby Target Elevation*, and *Winter Stage for Riparian* measures would
 3011 affect Columbia River flow upstream of Grand Coulee Dam. Figure 3-92 shows flows near RM
 3012 748 (just downstream of the U.S.-Canada border, about 151 river miles upstream of Grand
 3013 Coulee Dam).

3014 Figure 3-92 characterizes the timing and magnitude of flow changes between the No Action
 3015 Alternative and MO4 due to the combined effect of measures at Libby, Hungry Horse, and
 3016 Albeni Falls Dams. Changes in flow between MO4 and the No Action Alternative would be most
 3017 noticeable in December and in July. In December, the median flow for MO4 would be about 4
 3018 kcfs lower than for the No Action Alternative due to the *December Libby Target Elevation*
 3019 measure. In July, the flow for MO4 at the 75 percent exceedance level would be about 8 kcfs
 3020 higher than for the No Action Alternative, primarily due to operations for the *McNary Flow*
 3021 *Target* measure at Libby, Hungry Horse, and Albeni Falls Dams.



3022
 3023 **Figure 3-92. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 4**

3024 **Lake Roosevelt (Grand Coulee Dam Reservoir) Elevation**

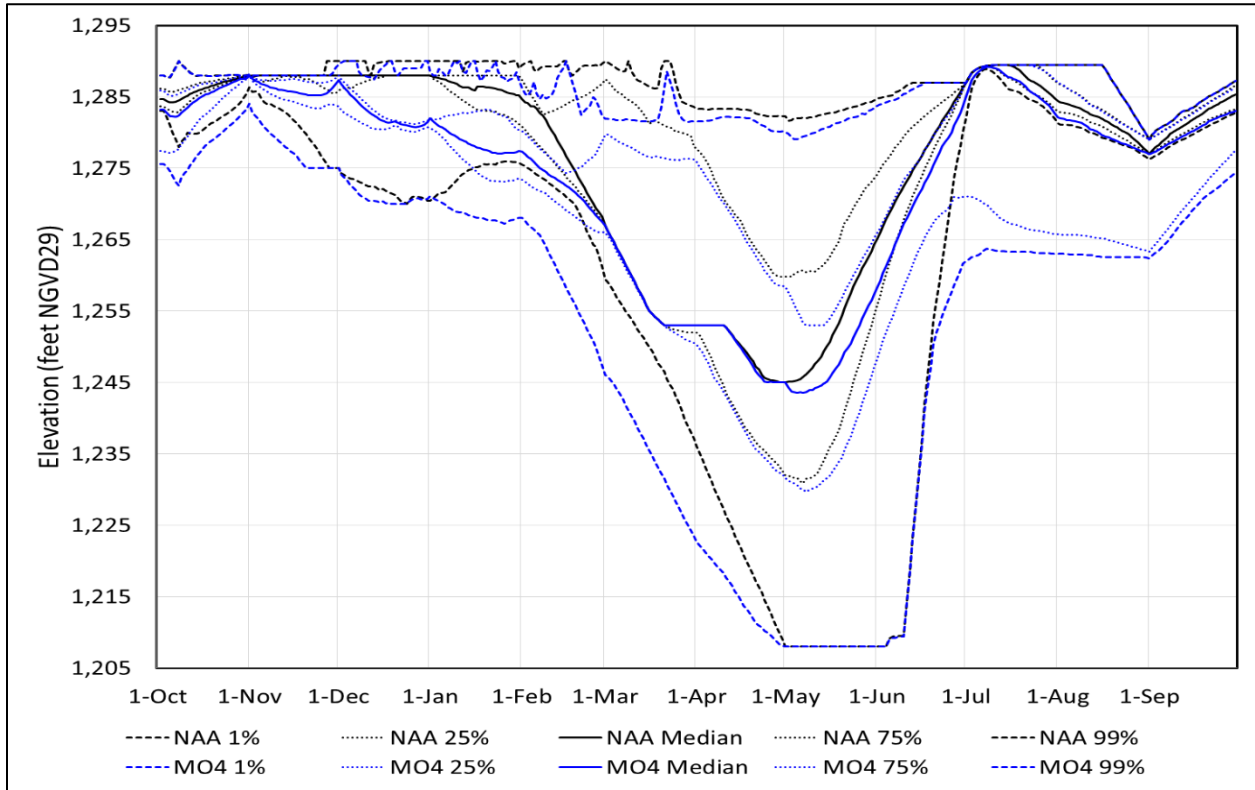
3025 Under MO4, the *McNary Flow Target*, *Update System FRM Calculation*, *Planned Draft Rate at*
 3026 *Grand Coulee*, and *Winter System FRM Space* measures relate directly to Grand Coulee Dam
 3027 and would influence reservoir elevations at Lake Roosevelt.

3028 Under MO4, the *McNary Flow Target*, *Winter System FRM Space*, and *Planned Draft Rate at*
 3029 *Grand Coulee* measures would be the source of most changes in Lake Roosevelt’s elevation. The
 3030 *Update System FRM Calculation* measure would have an effect on elevation in some years. The
 3031 *Grand Coulee Maintenance Operations* and *Lake Roosevelt Additional Water Supply* measures
 3032 would not have an effect on the lake level, but would affect outflow and spill at Grand Coulee
 3033 Dam.

3034 In addition to the measures listed above, under MO4, the *McNary Flow Target*, *Sliding Scale at*
 3035 *Libby and Hungry Horse*, *Modified Draft at Libby*, *December Libby Target Elevation*, *Winter*
 3036 *Stage for Riparian*, and *Hungry Horse Additional Water Supply* measures would affect the inflow
 3037 to Grand Coulee Dam. The hydroregulation modeling performed for MO4 incorporates all of
 3038 these measures, but because each measure was not evaluated in isolation from the others,
 3039 drawing a direct linkage between a single measure and an effect is not always possible. The

3040 effects that would occur from a measure or combination of measures are identified and
 3041 discussed to the extent possible.

3042 Reservoir water levels in Lake Roosevelt under MO4 would differ from the No Action
 3043 Alternative, as shown in the summary hydrograph, Figure 3-93.



3044
 3045 **Figure 3-93. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 4**

3046 Under MO4, the end of September elevation would be below 1,283 feet NGVD29 50 percent of
 3047 the time, primarily due to the *McNary Flow Target* measure. In contrast, the No Action
 3048 Alternative has a 1,283 feet NGVD29 refill elevation objective by the end of September in all
 3049 years for resident fish considerations. In all but the driest of years, Lake Roosevelt would fill to
 3050 the same elevation by the end of October as the No Action Alternative. The November
 3051 elevations would generally be the same or lower than the No Action Alternative. Then, from
 3052 December through February in virtually all years, the reservoir would be lower than the No
 3053 Action Alternative. This is primarily due to the *Winter System FRM Space* measure, which would
 3054 increase the space available at Grand Coulee Dam for FRM in the winter months when rain-
 3055 induced floods may occur, and also by the *Planned Draft Rate at Grand Coulee* measure, which
 3056 decreases the daily draft rate in planning drawdown to the deepest draft point, as determined
 3057 by the *Update System FRM Calculation* measure. In the wettest years the *Planned Draft Rate at*
 3058 *Grand Coulee* measure requires earlier draft, but this earlier draft is largely started already due
 3059 to the *Winter System FRM Space* measure.

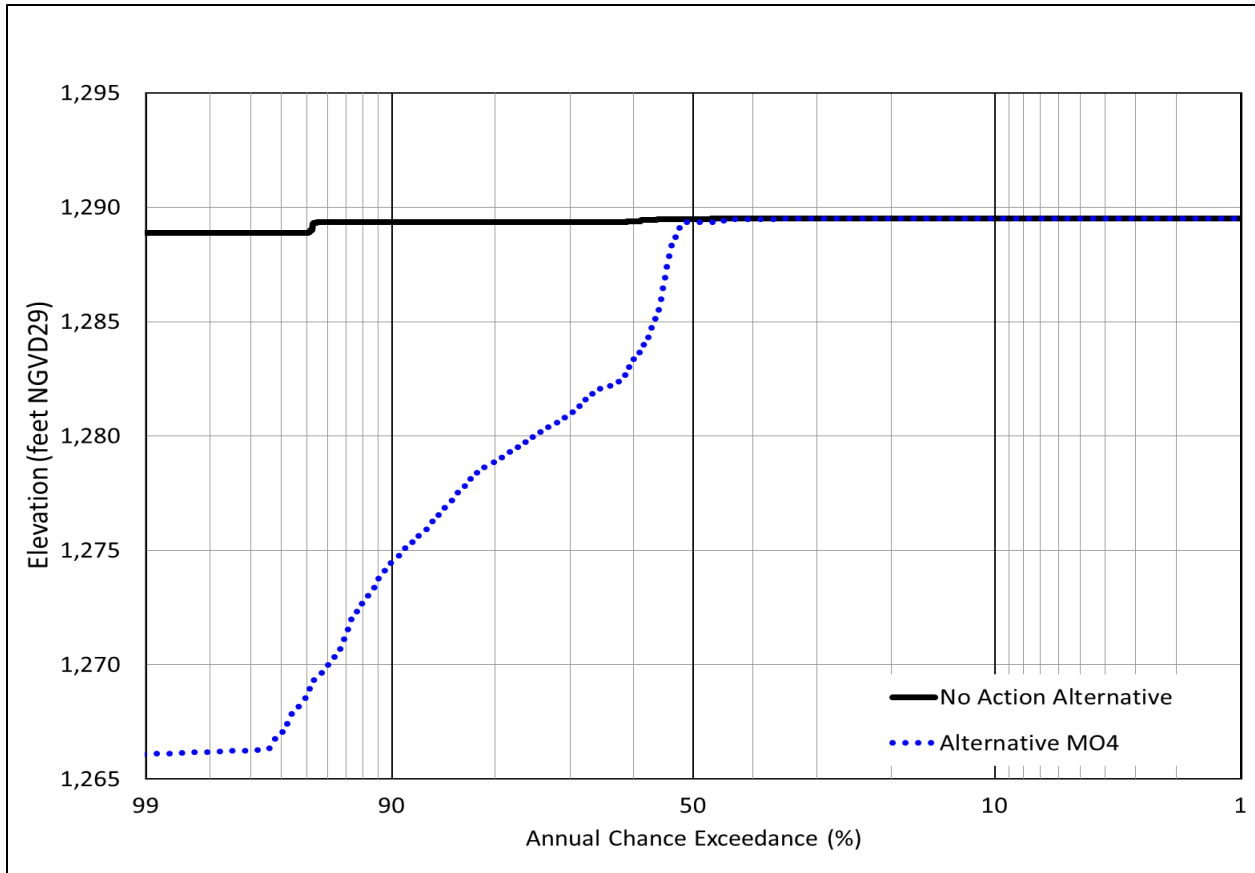
3060 At the end of December, the median reservoir elevation for MO4 would be about 7 feet lower
3061 than that for the No Action Alternative due to the *Winter System FRM Space* measure. The
3062 median reservoir elevation at the end of January would be about 8 feet lower than the No
3063 Action Alternative, primarily due to the *Winter System FRM Space* measure and also the
3064 combination of the *Planned Draft Rate at Grand Coulee* and *Updated System FRM Calculation*
3065 measures, which determines the deepest draft point. By the end of February and through the
3066 end of April, the median reservoir elevation under MO4 would be nearly identical to that for
3067 the No Action Alternative. However, the wetter years (depicted by the 25 percent and 1
3068 percent exceedance lines) and the drier years (depicted by the 75 percent and 99 percent
3069 exceedance lines) would continue with reservoir levels lower than the No Action Alternative
3070 from February through March, generally due to *Planned Draft Rate at Grand Coulee* measure.
3071 This trend would continue through April, due to a combination of several measures at Grand
3072 Coulee Dam, as well as measures at upstream projects.

3073 Under MO4, the probability of drafting to very low reservoir elevations (elevation 1,222 feet
3074 NGVD29 or below) at Lake Roosevelt on April 30 would increase when compared to the No
3075 Action Alternative. This is due to an element in the *Update System FRM Calculation* measure
3076 which calls for the FRM space requirement at Grand Coulee Dam to increase as the water
3077 supply forecast increases. This is in contrast to the FRM space requirement at Grand Coulee
3078 Dam for the No Action Alternative, which has a “flat spot” at elevation 1,222.7 feet NGVD29
3079 where the FRM space requirement does not increase right away with the runoff forecast over a
3080 certain range of runoff conditions.

3081 The effects of MO4 on the April 30 level of Lake Roosevelt are summarized below:

- 3082 • The chance of drawing the reservoir down to “empty” (elevation 1,208 feet NGVD29) on
3083 April 30 would be about 5 percent for MO4, the same as for the No Action Alternative.
- 3084 • The chance of drawing the reservoir down to elevation 1,222 feet NGVD29 or below on
3085 April 30 would be about 15 percent for MO4, as compared to about 8 percent for the No
3086 Action Alternative.

3087 In May, the level of Lake Roosevelt under MO4 would generally be lower than that for the No
3088 Action Alternative, mostly due to the effects of the *McNary Flow Target* measure, as shown in
3089 the summary hydrograph. When triggered, the *McNary Flow Target* measure would strive to
3090 maintain flow objectives at McNary Dam using water stored at Grand Coulee Dam as well as
3091 Libby, Hungry Horse, and Albeni Falls Dams. Up to 2.0 Maf of augmentation water from those
3092 four dams (combined), would be released, attempting to keep McNary flows above 220 kcfs
3093 from May 1 to June 15 and above 200 kcfs from June 16 to July 31 with a maximum daily
3094 augmentation of 40 kcfs per day. This would ultimately result in Lake Roosevelt not reaching its
3095 full elevation of 1,290 feet NGVD29 in about half of all years, as seen in the peak elevation
3096 frequency curve in Figure 3-94.

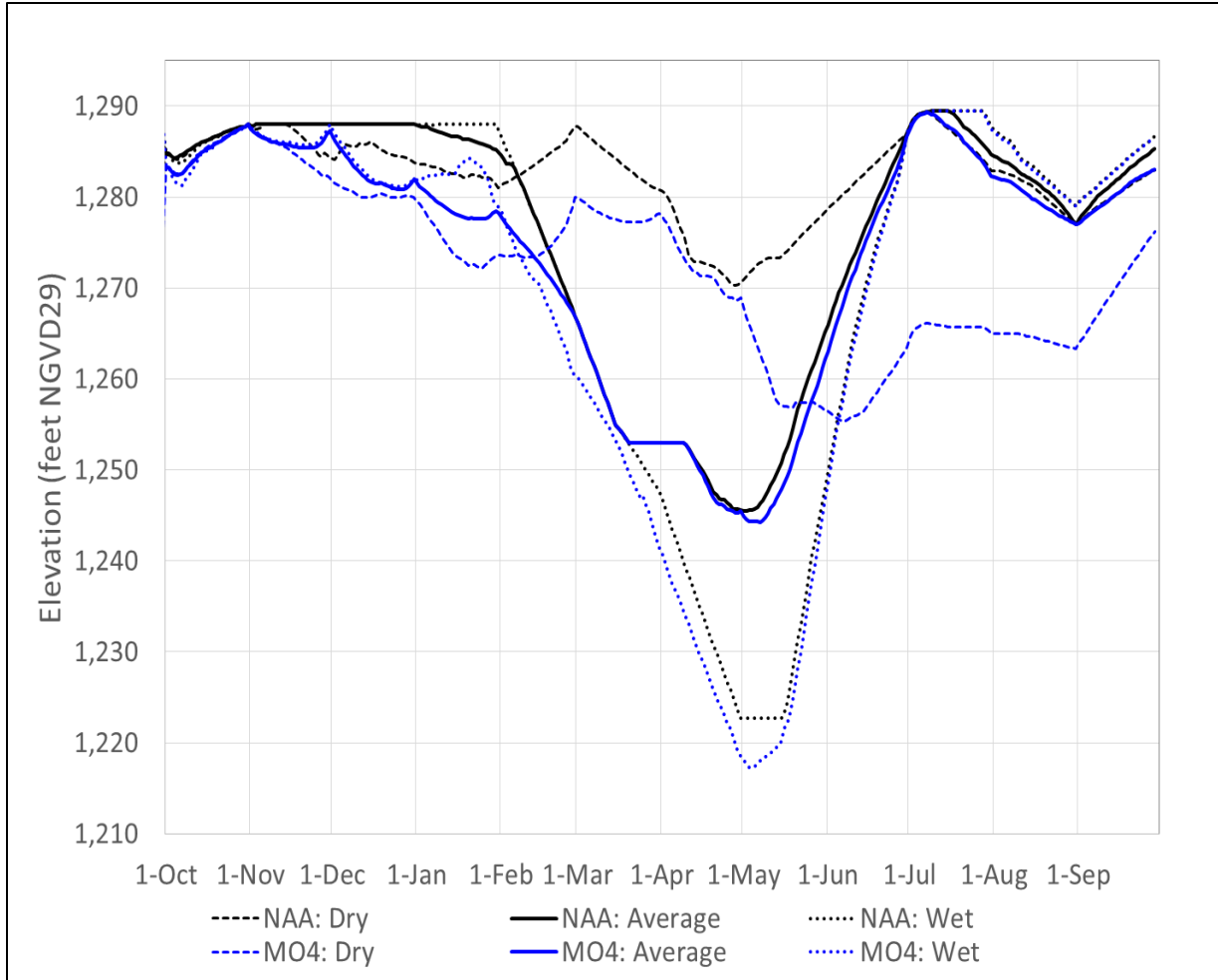


3097
 3098 **Figure 3-94. Lake Roosevelt Peak Elevation Frequency for Multiple Objective Alternative 4**

3099 Note: The full reservoir elevation for Lake Roosevelt is 1,290 feet NVGD29. It is represented as 1,289.5 feet
 3100 NGVD29 in the HEC-ResSim model, so appears as 1,289.5 feet NGVD29.

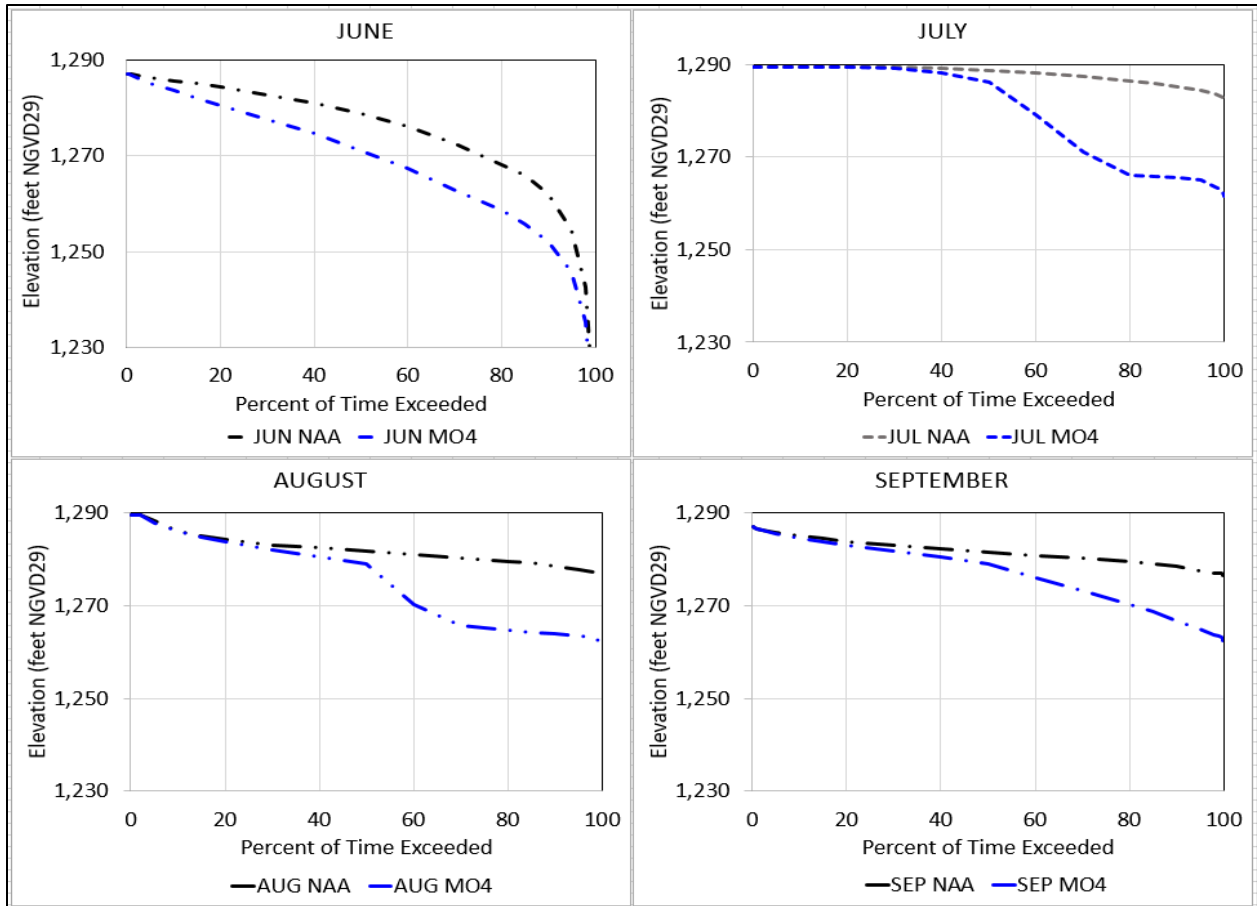
3101 Figure 3-95 provides another way to picture the effects described above, this time categorized
 3102 by water year type. From May through September, the median hydrographs show that the level
 3103 of Lake Roosevelt under MO4 would be much lower than for the No Action Alternative in dry
 3104 years. This is primarily due to the *McNary Flow Target* measure. It is important to note that
 3105 lower summer reservoir levels would occur in about half of all years, as shown in Figure 3-95,
 3106 and as will be shown in the elevation duration curves for summer months (Figure 3-94). The
 3107 median hydrograph figure for dry/average/wet years (Figure 3-95) cannot show the effect of
 3108 the *McNary Flow Target* measure occurring about half of the time due to way the
 3109 dry/average/wet categories are defined.

3110 Finally, elevation duration curves are useful for understanding how lake levels under MO4
 3111 would differ from the No Action Alternative. The four panels in Figure 3-96 show monthly
 3112 elevation duration curves for June, July, August, and September, respectively. The *McNary Flow*
 3113 *Target* measure would be triggered in years that are drier than average, and the effect of this
 3114 measure is seen in all four panels. For instance, in July and August the lake level would be lower
 3115 than the No Action Alternative about half of the time, with differences ranging from several
 3116 feet to about 20 feet.



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Figure 3-95. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative 4



3120

3121 **Figure 3-96. Lake Roosevelt Summer Elevations for Multiple Objective Alternative 4**

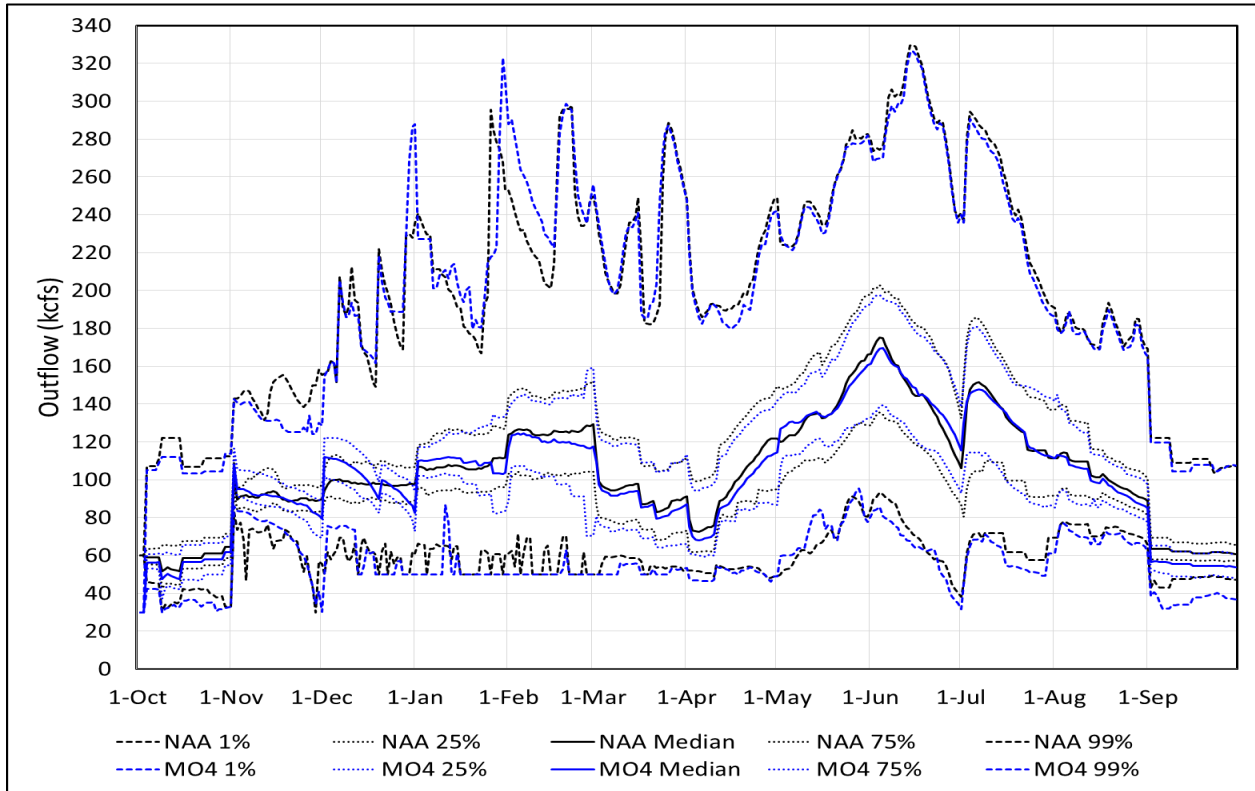
3122 **Grand Coulee Dam Drum Gate Maintenance**

3123 Drum gate maintenance at Grand Coulee Dam is planned to occur annually during March, April,
 3124 and May, but is not conducted in all years. The reservoir must be at or below elevation 1,255
 3125 feet NGVD29 for 8 weeks to complete drum gate maintenance. Under MO4 the *McNary Flow*
 3126 *Target, Update System FRM Calculation, Planned Draft Rate at Grand Coulee, and Winter*
 3127 *System FRM Space* measures would influence reservoir elevations during spring months.

3128 The changes in elevations for MO4 that influence the decision to conduct drum gate
 3129 maintenance would not change significantly relative to the No Action Alternative (April 30 FRM
 3130 elevation targets and drum gate initiation methodology is discussed in more detail in Part 1 of
 3131 Appendix B). The decision to conduct drum gate maintenance is based on the February water
 3132 supply forecast and the resulting April 30 FRM elevation projection (April 30 FRM elevation
 3133 target at or below 1,255 or 1,265 feet NGVD29 depending on how recently the maintenance
 3134 has been conducted). That is not to say the spring elevations are the same for the two
 3135 alternatives but rather there are a similar number of years that elevations would allow for drum
 3136 gate maintenance. In both MO4 and the No Action Alternative, drum gate maintenance would
 3137 be achievable in 65 percent of the years.

3138 **Grand Coulee Dam Outflow**

3139 Under MO4, the *McNary Flow Target, Update System FRM Calculation, Planned Draft Rate at*
 3140 *Grand Coulee, Winter System FRM Space, and Lake Roosevelt Additional Water Supply*
 3141 measures would affect Grand Coulee Dam outflow. In addition, the *McNary Flow Target, Sliding*
 3142 *Scale at Libby and Hungry Horse, Modified Draft at Libby, December Libby Target Elevation,*
 3143 *Winter Stage for Riparian, and Hungry Horse Additional Water Supply* measures would affect
 3144 inflows and outflows at Grand Coulee Dam. The outflows from Grand Coulee Dam would differ
 3145 from the No Action Alternative depending on the time of year, as seen in Figure 3-97.



3146
 3147 **Figure 3-97. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective**
 3148 **Alternative 4**

3149 The change in average monthly outflow throughout the water year is presented in Table 3-46.

3150 Under MO4, the *McNary Flow Target, Winter System FRM Space, the Planned Draft Rate at*
 3151 *Grand Coulee, and Lake Roosevelt Additional Water Supply* measures would result in the largest
 3152 changes in Grand Coulee Dam outflow. However, because there are so many measures in MO4
 3153 that would affect Grand Coulee Dam’s outflow, the effects are described below and the
 3154 measure (or combination of measures) causing the effect is identified where possible.

3155 **Table 3-46. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 4**
3156 **(as change from No Action Alternative)**

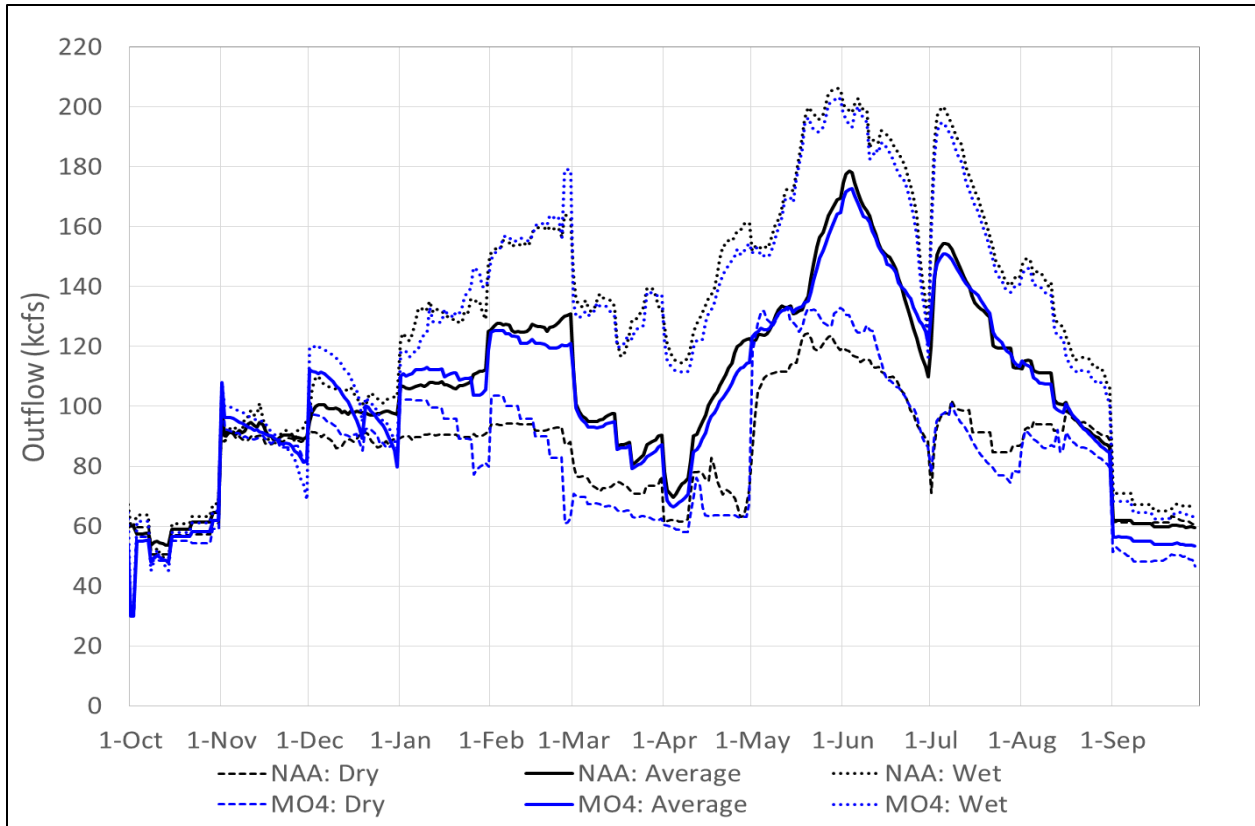
		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. Mo. Outflow (kcf)	1%	94	130	174	190	213	186	191	231	275	247	175	111
		25%	67	99	109	124	147	117	120	165	181	158	118	68
		50%	59	91	97	108	126	93	97	138	150	134	102	63
		75%	54	84	88	96	105	78	79	118	121	98	92	59
		99%	49	78	79	76	81	66	60	97	91	81	81	53
MO4	Change (kcf)	1%	-1.8	-0.4	-0.3	1.8	16.6	-2.3	-6.2	-4.3	-2.0	-5.4	-2.5	-2.9
		25%	-5.0	-1.9	0.8	-1.5	-3.2	0.0	-5.2	-5.7	-2.7	-1.9	-3.1	-5.1
		50%	-5.1	-1.4	2.7	1.4	-4.3	-2.5	-5.2	-2.7	-0.5	-0.6	-2.6	-6.3
		75%	-5.8	-0.1	3.6	2.3	-5.3	-4.9	-3.9	6.0	6.1	1.9	-3.7	-8.6
		99%	-7.6	-1.6	2.0	9.0	0.0	-5.6	-1.9	11.4	1.1	-5.1	-3.9	-9.2
	Percent change	1%	-2%	0%	0%	1%	8%	-1%	-3%	-2%	-1%	-2%	-1%	-3%
		25%	-8%	-2%	1%	-1%	-2%	0%	-4%	-3%	-1%	-1%	-3%	-8%
		50%	-9%	-2%	3%	1%	-3%	-3%	-5%	-2%	0%	0%	-3%	-10%
		75%	-11%	0%	4%	2%	-5%	-6%	-5%	5%	5%	2%	-4%	-15%
		99%	-15%	-2%	2%	12%	0%	-9%	-3%	12%	1%	-6%	-5%	-17%

3157 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO4 flows lower than the No
3158 Action Alternative flows; green shading denotes MO4 flows higher than the No Action Alternative flows.

- 3159 • Under MO4, outflows in October would generally be lower than the No Action Alternative
3160 due to the carryover effects from the *McNary Flow Target* measure. The median value of
3161 the monthly average discharge would be 5.1 kcf less than the No Action Alternative.
- 3162 • In December, the median value of the monthly average outflow would increase by 2.7 kcf.
3163 This is primarily due to the *Winter System FRM Space* measure which creates winter FRM
3164 space in Grand Coulee’s reservoir. The *December Libby Target Elevation* measure at Libby
3165 Dam counteracts the effect of the *Winter System FRM Space* measure at Grand Coulee Dam
3166 by generally reducing inflows by 4 kcf (reduction at median level), as mentioned in the
3167 previous section on Columbia River upstream of Grand Coulee Dam. In January, the median
3168 value of the monthly average outflow would increase by 1.4 kcf. This may be caused by the
3169 *Winter System FRM Space* measure, which continues to draft Grand Coulee’s reservoir in
3170 January if the winter FRM space is not achieved by the end of December. The *Update*
3171 *System FRM Calculation and Planned Draft Rate at Grand Coulee* measures can also
3172 influence flows in January.
- 3173 • In February and March, the median value of the monthly average outflow would decrease
3174 by 4.3 and 2.5 kcf, respectively. In March, the *Lake Roosevelt Additional Water Supply*
3175 measure would reduce flows approximately 0.6 kcf.
- 3176 • In April the volume of water to be pumped from Lake Roosevelt into Banks Lake as a result
3177 of the *Lake Roosevelt Additional Water Supply* measure would increase. The April through
3178 September period would have the greatest total pumping volumes, as well as the greatest
3179 additional pumping volumes as called for in the *Lake Roosevelt Additional Water Supply*
3180 measure.

- 3181 • In April, the median value of the monthly average outflow would decrease by 5.2 kcfs. The
3182 *Lake Roosevelt Additional Water Supply* measure's increased pumping from Lake Roosevelt
3183 into Banks Lake accounts for the majority (3.2 kcfs) of this decrease. The *Update System*
3184 *FRM Calculation and Planned Draft Rate at Grand Coulee* measures, as well as changes to
3185 inflow from measures changing operations at upstream storage projects, would also affect
3186 Grand Coulee Dam outflows in April.
- 3187 • The median value of the monthly average outflow would decrease by 2.7, 0.5, and 0.6 kcfs
3188 for May, June, and July, respectively. However, the 75 percent exceedance monthly average
3189 outflows would increase by 6.0, 6.1, and 1.9 kcfs, respectively, for those 3 months. A
3190 combination of multiple measures would cause these changes, with the *Lake Roosevelt*
3191 *Additional Water Supply* and *McNary Flow Target* measures being major drivers. The *Lake*
3192 *Roosevelt Additional Water Supply* measure's increased pumping from Lake Roosevelt into
3193 Banks Lake would reduce outflows, while the *McNary Flow Target* measure's releases for
3194 McNary flow targets would increase outflows in the drier-than-normal years when it is
3195 triggered. The *Lake Roosevelt Additional Water Supply* measure would cause flow decreases
3196 of 4.2, 2.6, and 2.5 kcfs in July, August, and September respectively. In the very driest of
3197 years, the augmentation water for McNary flow targets would be used up before July, and
3198 thus not be available in July. The overall combined effect of these and other measures is
3199 that some years would have higher outflows while other years would have lower outflows.
- 3200 • In August and September, the median value of the monthly average outflow would be
3201 reduced by 2.6 and 6.3 kcfs, respectively. The 75 percent exceedance monthly average
3202 outflows would have even greater reductions. The *Lake Roosevelt Additional Water Supply*
3203 measure would contribute to these reductions, as would the *McNary Flow Target* measure,
3204 when triggered.
- 3205 • The *Grand Coulee Maintenance Operations* measure would not impact reservoir elevations
3206 or total outflows, but would reduce the hydraulic capacity through the power plants,
3207 resulting in additional spill and an increase in TDG in some situations.

3208 Finally, median hydrographs for Grand Coulee Dam outflow in dry, average, and wet years are
3209 shown in Figure 3-98. The figure provides another way to picture the effects described above,
3210 this time categorized by water year type. Comparing the median hydrographs for dry years, it
3211 can be seen that during May and the first half of June, outflows from Grand Coulee Dam would
3212 be higher under MO4 than for the No Action Alternative. This is caused by the *McNary Flow*
3213 *Target* measure.



3214
 3215 **Figure 3-98. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective**
 3216 **Alternative 4**

3217 **Middle Columbia River below Grand Coulee Dam**

3218 Under MO4, the pattern of flow changes in the middle Columbia River would be similar to those
 3219 described for Grand Coulee Dam outflow, with the changes occurring for the same reasons as
 3220 described for Grand Coulee Dam outflow. An additional measure, *Chief Joseph Dam Project*
 3221 *Additional Water Supply*, calls for an increase in water diversion (at a maximum rate of 0.05
 3222 kcfs) from the Columbia River for Chief Joseph Dam. The total flow impact from the *Chief*
 3223 *Joseph Dam Project Additional Water Supply* measure is 9.6 kaf annually, which is significantly
 3224 smaller than the impacts from the *Lake Roosevelt Additional Water Supply* measure that
 3225 reduces flows an additional 1.1 Maf annually. For perspective, the flow change for the *Chief*
 3226 *Joseph Dam Project Additional Water Supply* measure is two orders of magnitude smaller than
 3227 that for the *Lake Roosevelt Additional Water Supply* measure. As compared to the *McNary Flow*
 3228 *Target* measure when triggered, the flow for the *Chief Joseph Dam Project Additional Water*
 3229 *Supply* measure may be three orders of magnitude smaller than that for the *McNary Flow*
 3230 *Target* measure. The reservoir elevation at Chief Joseph Dam would not change from the No
 3231 Action Alternative.

3232 Table 3-47 shows changes in the median values of monthly average flows at locations in middle
 3233 Columbia River.

3234 **Table 3-47. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative**
3235 **4 (as change from No Action Alternative)**

Location		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcfs)	Lake Roosevelt Inflow	64	82	92	95	100	65	69	131	166	133	98	75
	Grand Coulee	59	91	97	108	126	93	97	138	150	134	102	63
	Chief Joseph	58	91	96	108	127	94	98	139	150	135	103	63
	Wells	59	93	98	110	129	95	101	150	163	141	105	65
	Priest Rapids	60	96	102	115	133	100	108	162	178	147	108	68
Change (kcfs)	Lake Roosevelt Inflow	-0.2	-1.0	-3.8	1.8	1.8	0.4	-0.9	-2.8	0.4	1.0	1.1	-0.5
	Grand Coulee	-5.1	-1.4	2.7	1.4	-4.3	-2.5	-5.2	-2.7	-0.5	-0.6	-2.6	-6.3
	Chief Joseph	-4.6	-1.8	3.2	1.5	-4.1	-2.7	-5.3	-2.9	0.2	-1.4	-2.0	-5.9
	Wells	-3.2	-2.2	3.3	1.7	-3.8	-2.5	-5.2	-3.3	-1.2	-1.7	-1.8	-6.1
	Priest Rapids	-3.0	-1.0	3.8	1.6	-4.0	-2.3	-5.3	-3.9	-2.2	-1.8	-1.7	-6.2
Percent Change	Lake Roosevelt Inflow	0%	-1%	-4%	2%	2%	1%	-1%	-2%	0%	1%	1%	-1%
	Grand Coulee	-9%	-2%	3%	1%	-3%	-3%	-5%	-2%	0%	0%	-3%	-10%
	Chief Joseph	-8%	-2%	3%	1%	-3%	-3%	-5%	-2%	0%	-1%	-2%	-9%
	Wells	-6%	-2%	3%	2%	-3%	-3%	-5%	-2%	-1%	-1%	-2%	-9%
	Priest Rapids	-5%	-1%	4%	1%	-3%	-2%	-5%	-2%	-1%	-1%	-2%	-9%

3236 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO4 flows lower than the No
3237 Action Alternative flows; green shading denotes MO4 flows higher than the No Action Alternative flows.

3238 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
3239 **HARBOR DAMS**

3240 **Dworshak Dam**

3241 MO4 does not have any operational measures that would directly affect Dworshak Reservoir
3242 elevations or Dworshak Dam outflows. Given this, the effects would be the same as those for
3243 the No Action Alternative.

3244 **Lower Snake River Reservoir Elevations**

3245 Under MO4, the reservoir elevations at the four lower Snake River dams would have an
3246 adjusted MOP operation from March 15 through August 15 due to the *Drawdown to MOP*
3247 measure. At all four projects, the seasonal MOP range is increased from a 1.0-foot range to a
3248 1.5-foot range, each with a 0.5-foot increase in the upper end of the range. The proposed
3249 elevation ranges for March 15 through August 15 at each of the four projects are described
3250 below:

- 3251 • Lower Granite Dam: 733.0 to 734.5 feet NGVD29, compared to 733.0 to 734.0 feet NGVD29
3252 for the No Action Alternative
- 3253 • Little Goose Dam: 633.0 to 634.5 feet NGVD29, compared to 633.0 to 634.0 feet NGVD29
3254 for the No Action Alternative
- 3255 • Lower Monumental Dam: 537.0 to 538.5 feet NGVD29, compared to 537.0 to 538.5 feet
3256 NGVD29 for the No Action Alternative
- 3257 • Ice Harbor Dam: 437.0 to 438.5 feet NGVD29, compared to 437.0 to 438.5 feet NGVD29 for
3258 the No Action Alternative

3259 **Clearwater River below Dworshak Dam and the Lower Snake River**

3260 Under MO4, there are no changes at Dworshak Dam, so inflow to the lower Snake River would
3261 be unchanged from the No Action Alternative. The changes in MOP ranges at the lower Snake
3262 River reservoirs would have negligible effects on flow.

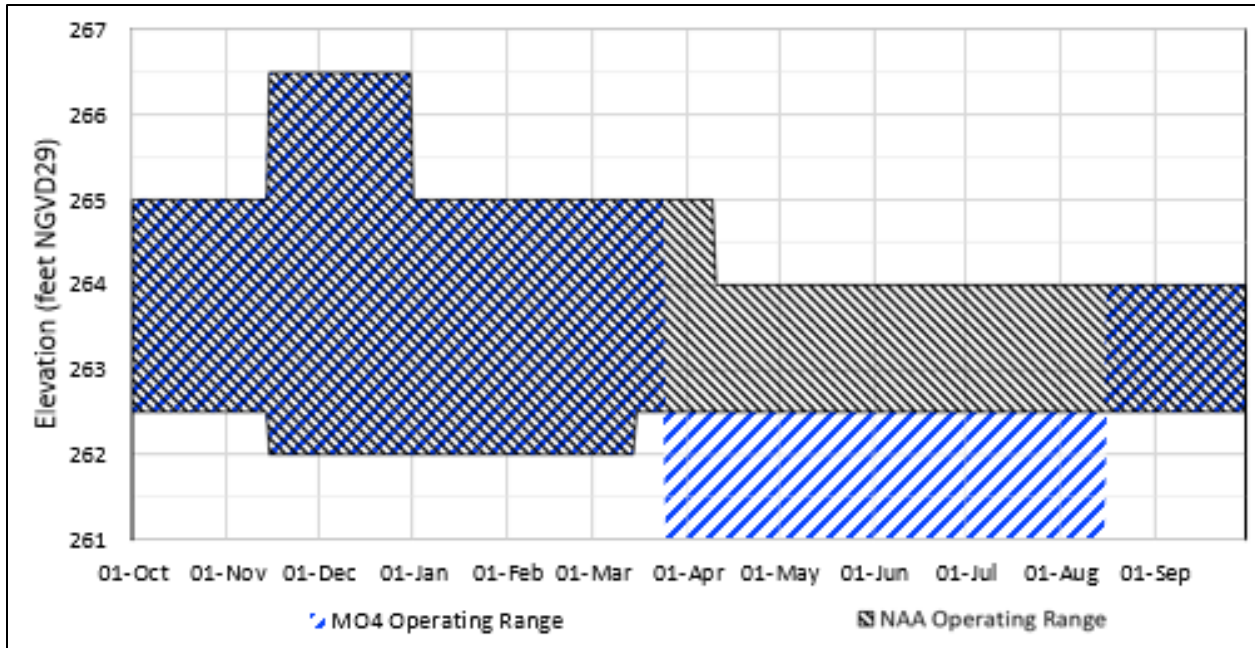
3263 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3264 **Lower Columbia River Reservoir Elevations**

3265 Under MO4, there would be changes to the reservoir elevations at McNary Dam, John Day
3266 Dam, The Dalles Dam, and Bonneville Dam. All would have an adjusted operating range because
3267 of *Drawdown to MOP* measure, which results in decreased operating range from March 25
3268 through August 15. The proposed MOP elevation ranges for each of the four projects and the
3269 changes from the No Action Alternative are described below:

- 3270 • McNary Dam would have a 1.0-foot MOP range from March 25 to August 15 (337.0 to 338.0
3271 feet NGVD29). This is a 2.0-foot decrease in operating range from the No Action Alternative,
3272 where McNary Dam does not have a MOP operation and the normal operating range is
3273 between 337.0 to 340.0 feet NGVD29.
- 3274 • John Day Dam would have a 1.5-foot range from March 25 to August 15 (261.0 to 262.5 feet
3275 NGVD29). This differs from the No Action Alternative, where John Day Dam operates
3276 between 262.5 to 265.0 feet NGVD29 from March 15 to April 9, and between 262.5 to 264.0
3277 feet NGVD29 from April 10 to September 30. In both periods, the new operating range
3278 minimum is shifted down 1.5 feet, and the range is decreased by 1.5 to 2.5 feet.
- 3279 • The Dalles Dam would have a 1.5-foot MOP range from March 25 to August 15 (155.0 to
3280 156.5 feet NGVD29). This is a 3.5-foot decrease in operating range from the No Action
3281 Alternative, where The Dalles Dam does not have a MOP operation and is operated
3282 between 155.0 to 160.0 feet NGVD29 year round.
- 3283 • Bonneville Dam would have a 1.5-foot MOP range from March 25 to August 15 (71.5 to 73.0
3284 feet NGVD29). This is a 3.5-foot decrease in operating range from the No Action Alternative,
3285 where Bonneville Dam does not have a MOP operation and is operated between 71.5 to
3286 76.5 feet NGVD29 year round.

3287 The operating range for John Day Dam for MO4 is shown in Figure 3-99. The No Action
3288 Alternative operating range is shown for comparison purposes.



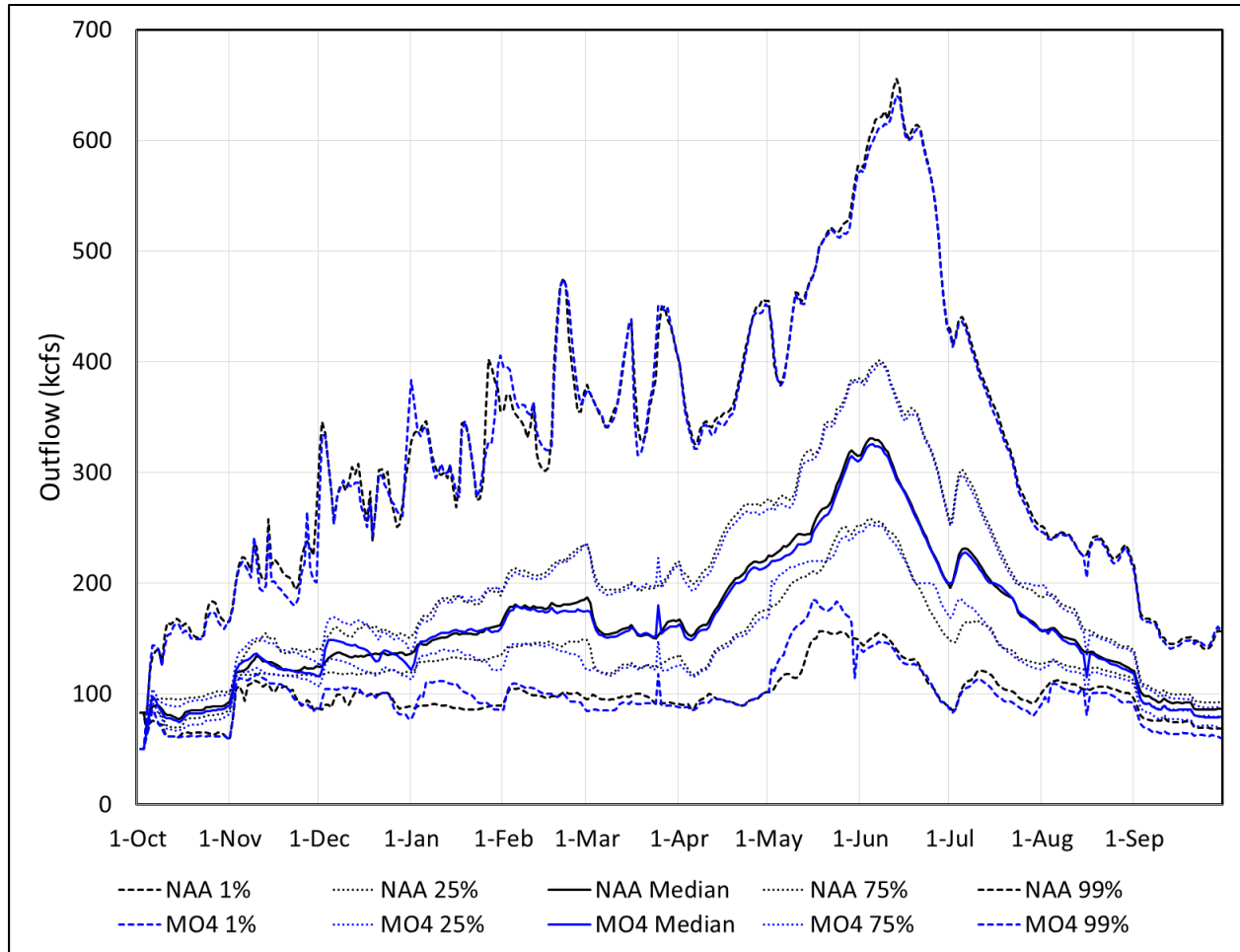
3289
 3290 **Figure 3-99. John Day Dam Operating Range for Multiple Objective Alternative 4**
 3291 Note: John Day may be operated between 257 feet and 268 feet NGVD29 for FRM purposes. These limits are not
 3292 shown on this figure in order to show greater detail in the vertical scale.

3293 **Lower Columbia River Flows**

3294 Under MO4, the *McNary Flow Target, Sliding Scale at Libby and Hungry Horse, Modified Draft*
 3295 *at Libby, December Libby Target Elevation, Update System FRM Calculation, Planned Draft Rate*
 3296 *at Grand Coulee, Winter System FRM Space, Lake Roosevelt Additional Water Supply, Hungry*
 3297 *Horse Additional Water Supply, Chief Joseph Dam Project Additional Water Supply, Drawdown*
 3298 *to MOP, and Winter Stage for Riparian* measures would cause changes in flow patterns in the
 3299 lower Columbia River.

3300 At McNary Dam, the outflows under MO4 would differ from the No Action Alternative to
 3301 various extents through the water year. The magnitude and timing of differences in flow are
 3302 displayed in the summary hydrograph, Figure 3-100. The flow spike that appears in mid-March,
 3303 as well as the flow dip that appears in mid-August, are both related to the way that changes in
 3304 pool levels were modeled for the *Drawdown to MOP* measure. This spike/dip would not be
 3305 expected to occur in actual implementation, as the elevation changes for starting and ending
 3306 MOP would be spread out over more than 1 day, thus smoothing out changes in releases.

3307 In addition to the daily flow values depicted in Figure 3-100, the monthly average outflows from
 3308 McNary Dam that would occur under MO4 were compared to those for the No Action
 3309 Alternative, as shown in Table 3-48.



3310
 3311
 3312

Figure 3-100. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 4

3313 Several conclusions can be drawn from this comparison:

- 3314 • In December and January, the median value of monthly average outflow would increase by
 3315 3.0 and 1.7 kcfs, respectively. There would be increases for other exceedance values as well.
 3316 For instance, the 75 percent exceedance values in December and January would increase by
 3317 5.0 and 2.6 kcfs, respectively. The *Winter System FRM Space* measure calling for winter FRM
 3318 space at Grand Coulee Dam is the main reason for these flow increases.
- 3319 • In March and April, monthly average outflow would be less than the No Action Alternative
 3320 at all flow levels.
- 3321 • In May, June, and July, the 75 percent exceedance values of monthly average outflow would
 3322 increase by 2.3, 8.9, and 6.1 kcfs, respectively. And in the very driest years (reflected in the
 3323 99 percent exceedance value), the monthly average outflow in May would be 21.5 kcfs
 3324 higher than for the No Action Alternative. The *McNary Flow Target* measure is the main
 3325 reason for these flow increases.
- 3326 • In August, September, October, and November, monthly average outflow would be less
 3327 than the No Action Alternative at all flow levels.

3328 **Table 3-48. McNary Dam Monthly Average Outflow for Multiple Objective Alternative 4 (as**
3329 **change from No Action Alternative)**

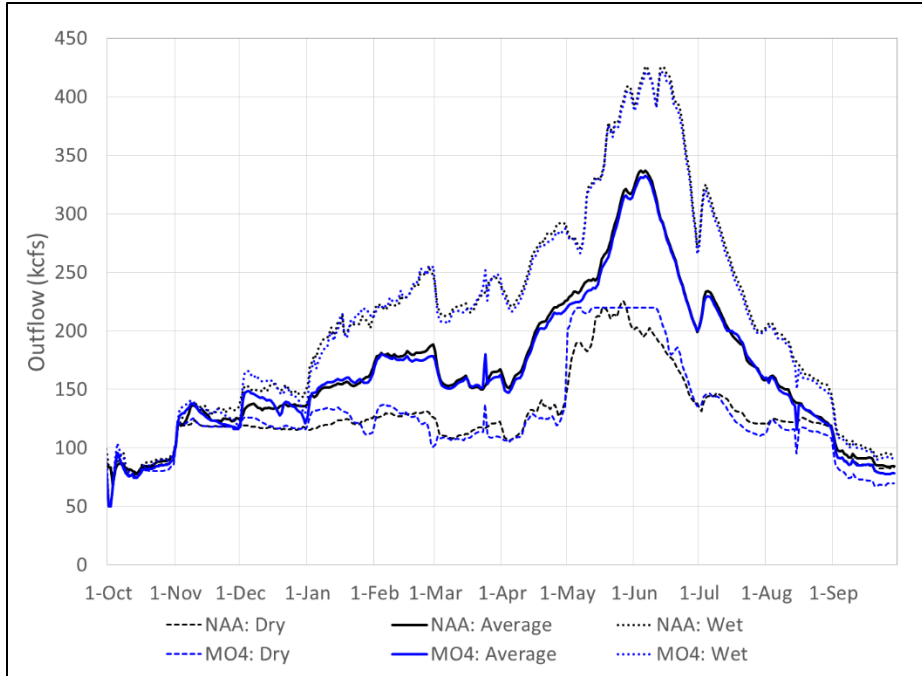
		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	141	187	279	280	327	329	346	451	562	342	231	152
		25%	95	143	155	181	216	200	236	313	352	243	163	100
		50%	85	124	136	154	182	159	192	260	285	198	141	93
		75%	79	116	118	133	147	130	147	231	217	147	124	87
		99%	73	112	109	108	115	107	106	178	160	122	114	81
MO4	Change (kcfs)	1%	-8.0	-1.5	-2.3	2.9	4.4	-2.3	-5.1	-1.5	-4.3	-4.5	-2.9	-3.1
		25%	-4.7	-2.4	1.7	-3.6	-3.5	-0.5	-6.8	-5.2	-4.4	-4.3	-3.7	-3.2
		50%	-4.1	-1.8	3.0	1.7	-3.1	-1.4	-5.5	-4.5	-2.5	0.7	-2.3	-6.2
		75%	-5.2	-0.1	5.0	2.6	-5.7	-2.9	-4.0	2.3	8.9	6.1	-4.0	-8.7
		99%	-5.7	-2.8	-0.3	7.5	0.4	-5.7	-2.6	21.5	-1.5	-7.0	-6.6	-10.5
	Percent change	1%	-6%	-1%	-1%	1%	1%	-1%	-1%	0%	-1%	-1%	-1%	-2%
		25%	-5%	-2%	1%	-2%	-2%	0%	-3%	-2%	-1%	-2%	-2%	-3%
		50%	-5%	-1%	2%	1%	-2%	-1%	-3%	-2%	-1%	0%	-2%	-7%
		75%	-7%	0%	4%	2%	-4%	-2%	-3%	1%	4%	4%	-3%	-10%
		99%	-8%	-3%	0%	7%	0%	-5%	-2%	12%	-1%	-6%	-6%	-13%

3330 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO4 flows lower than the No
3331 Action Alternative flows; green shading denotes MO4 flows higher than the No Action Alternative flows.

3332 Finally, median hydrographs for McNary Dam outflow in dry, average, and wet years are shown
3333 in Figure 3-101. MO4 and the No Action Alternative results are shown. With the results
3334 categorized by water year type, it is readily seen that the *McNary Flow Target* measure's flow
3335 objective of 220 kcfs in the spring would generally be achieved. The summertime objective of
3336 200 kcfs (from June 16 to July 31), which is also part of the *McNary Flow Target* measure, would
3337 generally not be achieved in average and dry years. In September, the flows at McNary Dam
3338 under MO4 would be lower than for the No Action Alternative in average and dry years, with
3339 the difference being most pronounced in dry water years.

3340 Along the lower Columbia River, the median value of the average monthly flow for MO4 would
3341 be higher than the No Action Alternative in some months (for example, December, January, and
3342 July), and lower in others (for example, April, May, June, August, and September). The flow
3343 change patterns seen at the confluence of the Columbia and Snake Rivers continue
3344 downstream to other locations. This is seen in Table 3-49.

3345 With the exception of effects of the *Drawdown to MOP* measure at John Day, the effects on
3346 McNary Dam outflow from MO4 would occur similarly, and for the same reasons, at John Day
3347 Dam, The Dalles Dam, and Bonneville Dam. The measure would result in an increase in March
3348 flows and a decrease in August, reversing the flow trend shown in the McNary Dam outflow for
3349 March, and adding to the decrease shown in August.



3350
3351 **Figure 3-101. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective**
3352 **Alternative 4**

3353 **Table 3-49. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 4**
3354 **(as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (kcfs)	Columbia+ Snake	83	122	134	151	181	157	188	260	288	199	140	91
	McNary	85	124	136	154	182	159	192	260	285	198	141	93
	John Day	85	125	140	156	185	165	198	267	288	197	141	93
	The Dalles	90	130	146	163	192	172	206	273	293	202	146	97
	Bonneville	91	135	152	170	199	179	213	275	296	204	149	99
	Columbia+ Willamette	108	178	225	252	267	233	260	314	319	216	159	111
	Columiba+ Cowlitz	115	196	257	282	295	255	283	334	336	226	165	117
Change (kcfs)	Columbia+ Snake	-2.8	-2.3	2.4	1.3	-3.6	-1.9	-5.8	-4.8	-3.4	0.4	-1.8	-6.0
	McNary	-4.1	-1.8	3.0	1.7	-3.1	-1.4	-5.5	-4.5	-2.5	0.7	-2.3	-6.2
	John Day	-4.4	-2.2	2.3	0.8	-3.2	0.2	-5.5	-5.4	-3.5	0.5	-3.3	-5.9
	The Dalles	-5.1	-1.9	2.3	1.1	-3.4	0.6	-4.8	-5.4	-3.2	0.6	-4.0	-5.8
	Bonneville	-3.1	-1.9	1.7	1.0	-3.3	1.6	-4.8	-4.4	-2.7	0.6	-5.8	-6.5
	Columbia+ Willamette	-4.2	-1.1	2.1	1.6	-4.1	2.1	-5.2	-4.1	-2.8	0.9	-6.0	-5.9
	Columiba+ Cowlitz	-4.1	0.7	3.0	2.1	-4.0	0.9	-5.5	-4.0	-3.5	1.5	-5.7	-5.8
Percent Change	Columbia+ Snake	-3%	-2%	2%	1%	-2%	-1%	-3%	-2%	-1%	0%	-1%	-7%
	McNary	-5%	-1%	2%	1%	-2%	-1%	-3%	-2%	-1%	0%	-2%	-7%
	John Day	-5%	-2%	2%	1%	-2%	0%	-3%	-2%	-1%	0%	-2%	-6%
	The Dalles	-6%	-1%	2%	1%	-2%	0%	-2%	-2%	-1%	0%	-3%	-6%
	Bonneville	-3%	-1%	1%	1%	-2%	1%	-2%	-2%	-1%	0%	-4%	-7%
	Columbia+ Willamette	-4%	-1%	1%	1%	-2%	1%	-2%	-1%	-1%	0%	-4%	-5%
	Columiba+Cowlitz	-4%	0%	1%	1%	-1%	0%	-2%	-1%	-1%	1%	-3%	-5%

3355 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes MO4 flows greater than the
3356 No Action Alternative flows; green shading denotes MO4 flows less than the No Action Alternative flows.

3357 **SUMMARY OF EFFECTS**

3358 Under MO4, the largest changes in water levels occur at Libby, Grand Coulee, and the lower
3359 Columbia River dams. Lake Koochanusa water levels are less variable in the winter and spring,
3360 with deeper drafts in low forecast years and less-deep drafts in large forecast years. August
3361 through November reservoir levels are lower in most years but can be higher in higher forecast
3362 years. Lake Roosevelt water levels are notably lower in the winter due to additional winter FRM
3363 space, slightly higher later in the year, and notably lower in the summer into the fall in low
3364 forecast years. At Hungry Horse Reservoir, additional water demand in the summer months
3365 results in slightly lower reservoir levels for most of the year, particularly in a low forecast year
3366 at The Dalles. The forebay operating range is slightly higher in the summer months at the lower
3367 Snake River projects and notably lower at the lower Columbia River projects. There are no
3368 changes at Dworshak Dam.

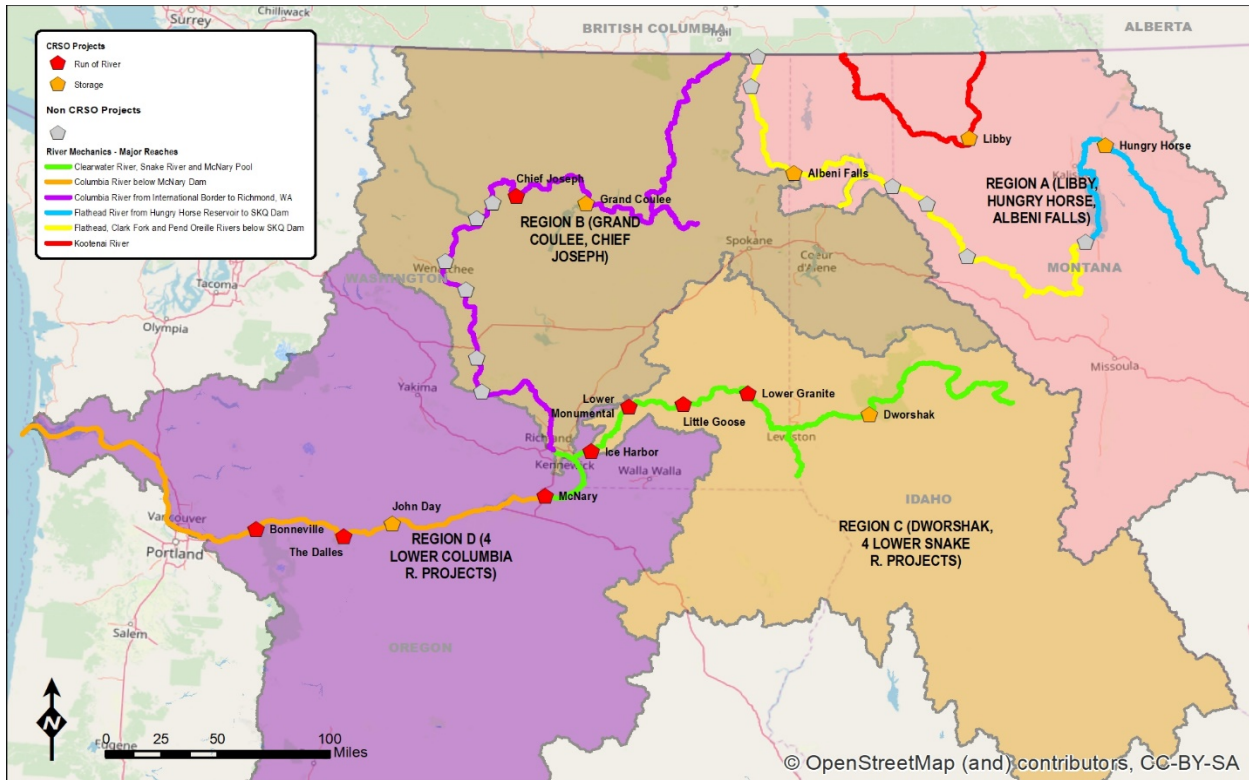
3369 Changes in Libby outflows vary greatly across the year; November and December releases are
3370 decreased, winter releases after December are notably higher, April and May releases are
3371 lower, and summer releases are higher, particularly in June and July in low forecast years at The
3372 Dalles. Due to additional water demands from Hungry Horse Dam, Flathead River flows are
3373 lower in winter and spring months. In low forecast years at The Dalles, Hungry Horse and Albeni
3374 Falls Dams release extra water in June and July, and these are followed by larger decreases in
3375 flow in the fall and winter months. Water supply delivery increases from Grand Coulee and
3376 Chief Joseph Dams contribute to lower spring and summer flows in the Columbia River
3377 downstream. In low forecast years at The Dalles, flows are increased May through July, and
3378 then further decreased in September and October. With the exception of September, which can
3379 be more than 10 percent lower in lower water years, changes in average monthly flow through
3380 the lower Columbia River are typically within 5 percent of the No Action Alternative for all
3381 months for typical years.

3382 **3.3 RIVER MECHANICS**

3383 This river mechanics section consists of four parts: (1) a description of the study area, (2) a
3384 summary of the baseline sediment transport and geomorphologic conditions for the study area,
3385 (3) a discussion of the methodology and quantitative metrics, and (4) an estimate of the
3386 potential impacts to river mechanics metrics under the No Action Alternative and four MOs.
3387 Relative impacts are then compared between the MOs and No Action Alternative. See Chapter
3388 7 for a description of impacts to river mechanics as a result of implementing the draft preferred
3389 alternative.

3390 **3.3.1 Area of Analysis**

3391 For the geomorphology and sediment transport discussions, the area of analysis is the CRS
3392 reservoirs and the river reaches downstream that are within the borders of the United States.
3393 River mechanics effects for reaches in Canada downstream of CRS reservoirs would be expected
3394 to be similar to the effects described in neighboring river reaches in the United States.
3395 Discussion of reaches in this chapter is organized by the four physiographic NEPA regions listed
3396 in Table 3-50 and depicted in Figure 3-102. Within each of the four lettered CRSO regions, the
3397 river mechanics analyses were subsequently grouped by the following: major reach, minor
3398 reach, and subreach, each representing a finer resolution level. In general, major reaches
3399 coincide physiographically with river segments or groups. Minor reaches were defined as
3400 reservoir or river segments between FCRPS projects, and subreaches were delineated by
3401 contiguous similarity in physical properties such as the following: valley type, morphology,
3402 energy grade slope, and flow depth. More information regarding the reach delineations is
3403 presented in Appendix C.



3404
3405 **Figure 3-102. Overview Map of Study Area Regions Used for River Mechanics Assessment**

3406 **Table 3-50. River Mechanics Study Area National Environmental Policy Act Regions**

CRSO Region	River Basins
A	Kootenai, Flathead, and Pend Oreille Rivers
B	Middle Columbia River
C	Clearwater and lower Snake Rivers
D	Lower Columbia River

3407 **3.3.1.1 Region A – Kootenai, Flathead, and Pend Oreille Basins**

3408 Region A includes the Kootenai, Flathead, and Pend Oreille Basins. There are nine
3409 hydroregulation projects located within Region A. Only three of the projects are CRS
3410 operated for storage (Libby Dam, Hungry Horse, and Albeni Falls). The remaining six
3411 projects (SKQ, Thompson Falls, Noxon Rapids, Cabinet Gorge, Box Canyon, and Boundary) are not part
3412 of the CRS but were included in the hydroregulation planning model to quantify potential
3413 departure in metrics that could result due to operational changes between the upper basin
3414 storage projects and the Columbia River.

3415 **REGION A – KOOTENAI RIVER**

3416 The Kootenai(y) River major reach lies within the NEPA Region A. The Libby Dam reservoir (Lake
3417 Kooconusa) extends upstream across the U.S.-Canada border, which forms the upstream end of
3418 the study area. The upper 70 miles of the Kootenai River is free flowing between Libby Dam and

3419 Bonners Ferry, Idaho. Downstream of Bonners Ferry is a backwatered reach which flows back
3420 across the U.S.-Canada border to Kootenay Lake, B.C., marking the downstream analysis extent.

3421 **REGION A – FLATHEAD RIVER FROM HUNGRY HORSE RESERVOIR TO SKQ DAM**

3422 The Flathead River from Hungry Horse Reservoir to SKQ Dam major reach lies within NEPA
3423 Region A and spans approximately 85 river miles. The Hungry Horse storage project lies within
3424 this major reach, and the upstream extent of Hungry Horse Reservoir coincides with the
3425 upstream extent of the study area. The Flathead River analysis area is free-flowing for
3426 approximately 28 river miles from the Hungry Horse Dam tailrace upstream to the confluence
3427 with the Stillwater River downstream. From there, the lower 20 river miles of the Flathead River
3428 are seasonally backwatered by Flathead Lake, which inundates the lower 35 miles of the reach.

3429 **REGION A – FLATHEAD, CLARK FORK, AND PEND OREILLE RIVERS BELOW SKQ DAM**

3430 The Flathead, Clark Fork, and Pend Oreille Rivers below SKQ Dam major reach lies within NEPA
3431 Region A. SKQ Dam on the Flathead River marks the upstream extent of this major reach. The
3432 Pend Oreille River, flowing across the U.S.-Canada border, marks the downstream reach extent.
3433 The Lower Clark Fork River subreach extends approximately 109 river miles from the
3434 confluence with the Flathead River upstream to Lake Pend Oreille downstream.

3435 There are three non CRS run-of-river projects within the subreach: Thompson Falls, Noxon
3436 Rapids, and Cabinet Gorge, which can locally influence Clark Fork River hydraulics. The Pend
3437 Oreille River subreach spans approximately 118 river miles between the Clark Fork River Delta
3438 on Lake Pend Oreille upstream to Boundary Dam downstream at the U.S.-Canada border in
3439 northeast Washington. There is one CRS storage project (Albeni Falls) and two non-CRS run-of-
3440 river projects (Box Canyon and Boundary) that influence hydraulics within the reach.
3441 Downstream of Boundary Dam, the Pend Oreille River flows north into Canada where it joins
3442 the Columbia River approximately 17 miles downstream near Waneta Dam, B.C.

3443 **3.3.1.2 Region B – Middle Columbia River**

3444 Region B includes the middle Columbia River Basin as it enters the United States from Canada.
3445 The middle Columbia River Basin analysis reach spans approximately 413 river miles from the
3446 U.S.-Canada border upstream in northeastern Washington to Richland, Washington,
3447 downstream near the Yakima River confluence. The downstream extent of this major reach
3448 ends at the transition from the free-flowing Hanford Reach to the backwatered McNary
3449 Reservoir.

3450 There are seven hydroregulation projects located within Region B (Grand Coulee, Chief Joseph,
3451 Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids). Only one of the Region B
3452 projects (Grand Coulee) is operated for storage; two of the projects (Grand Coulee and Chief
3453 Joseph) have modified operational measures under the CRSO EIS. The remaining five private
3454 non-Federal projects downstream of Chief Joseph are all run-of-river and are not part of the
3455 CRS; however, they were included in the hydroregulation planning model to quantify potential

3456 departure in metrics that could result due to operational changes between Lake Roosevelt
3457 upstream and the lower Columbia River downstream.

3458 **3.3.1.3 Region C – Clearwater and Lower Snake Rivers**

3459 Analysis Region C includes the Clearwater and lower Snake River Basins in western Idaho and
3460 eastern Washington. There are five hydroregulation projects located within Region C that have
3461 modified operational measures under the CRSO EIS. Only one of the projects (Dworshak) on the
3462 Clearwater River is operated for storage, while the remaining four on the lower Snake River
3463 below Lewiston, Idaho (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor), are
3464 run-of-river projects. The Clearwater River study minor reach spans approximately 42 river
3465 miles from Dworshak Dam to the confluence with the Snake River near Lewiston, Idaho. The
3466 lower Snake River minor reach spans approximately 168 river miles from above the Grande
3467 Ronde River confluence upstream to the Columbia River confluence near Pasco, Washington,
3468 downstream. There is an authorized navigation channel between the Snake River confluence
3469 with the Columbia River and the city of Lewiston, Idaho, in the Lower Granite Reservoir that is
3470 part of this major reach.

3471 **3.3.1.4 Region D – Lower Columbia River**

3472 Region D includes the Columbia River below Richland, Washington. There are four
3473 hydroregulation projects located within Region D that have modified operational measures
3474 under the CRSO EIS (McNary, John Day, The Dalles, and Bonneville Dam). These projects
3475 generally operate as run-of-river projects, even though there is a small amount of storage at
3476 John Day Dam. The upstream extent of Region D begins at the downstream extent of Region B
3477 near the confluence of the Columbia and Yakima Rivers as well as the downstream extent of
3478 Region C (at the confluence of the Columbia and Snake Rivers). The lower Columbia River reach
3479 extends approximately 316 river miles from the confluence with the Yakima River upstream to
3480 the mouth of the Columbia River downstream near Astoria, Oregon. There is an authorized
3481 navigation channel between RM 3 near the Pacific Ocean and McNary Reservoir that is also part
3482 of this major reach.

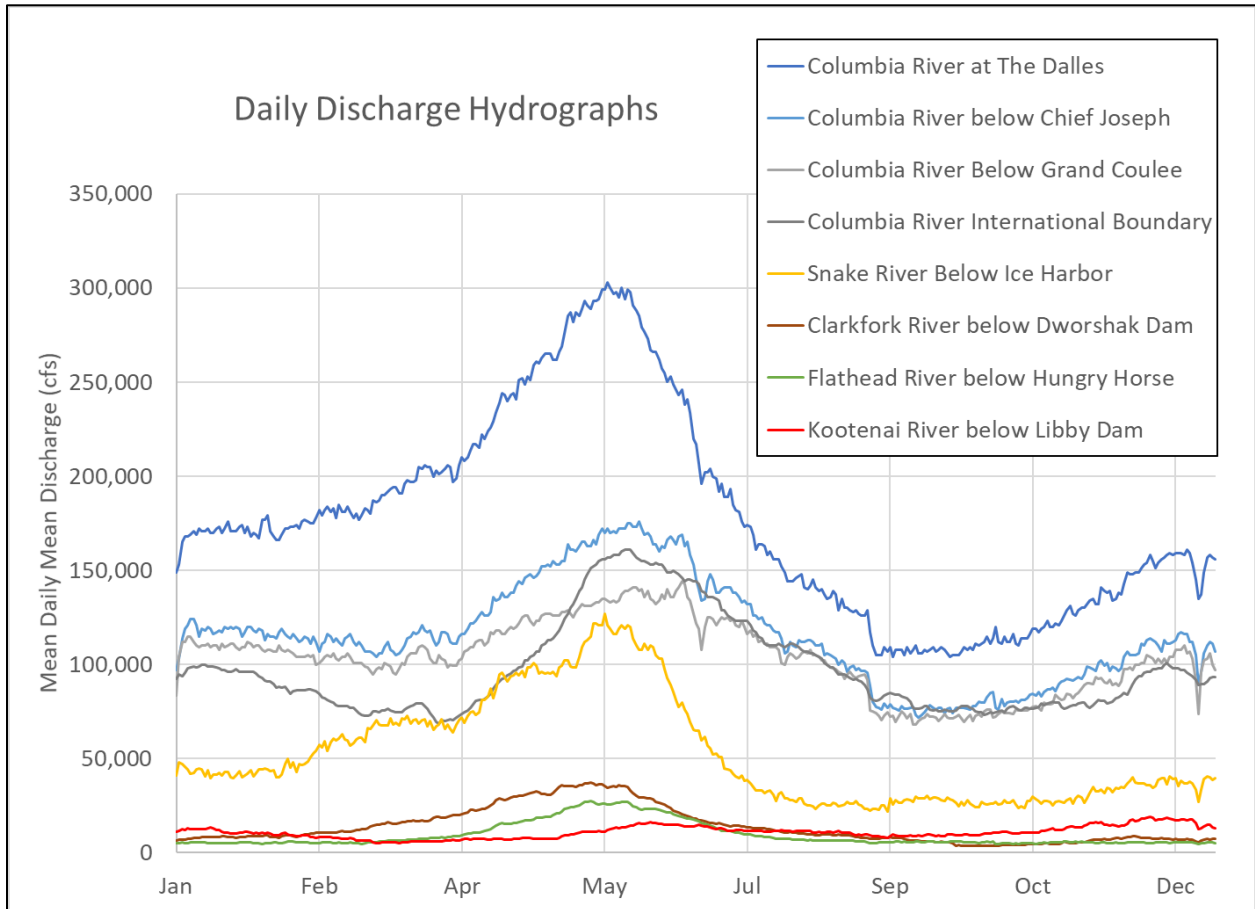
3483 **3.3.2 Affected Environment**

3484 For this EIS analysis, river mechanics response in the analysis area is a combined function of the
3485 following: hydrology, sediment supply, and hydraulic response which is driven by slope, channel
3486 geometry, and roughness. Hydraulic response within the system is characterized by three major
3487 types: storage reservoirs, run-of-river reservoirs, and free-flowing reaches. The baseline
3488 characteristics for the affected environment analysis area are summarized in the following
3489 section.

3490 **3.3.2.1 Hydrology**

3491 The typical mean daily flows throughout the year at a few key locations in the Columbia River
3492 Basin are shown in Figure 3-103. The largest alteration to flow occurs at storage dams, which

3493 are operated to balance various flow release and water storage needs according to the
3494 operational goals for each project. Because of flow regulation, high discharges during the flood
3495 season (spring freshet period) are less frequent than during pre-regulation (pre-1930s) times;
3496 conversely, there are typically higher discharges during the summer and fall than during pre-
3497 regulation times.



3498 **Figure 3-103. Mean Daily Mean Discharges at U.S. Geological Survey Gages**
3499 Note: Data is for water years 1977 to 2017 downstream of storage dams, at Chief Joseph Dam, at Ice Harbor Dam
3500 just upstream of the confluence of the Snake River with the Columbia River, and at the U.S.-Canada border.
3501

3502 **3.3.2.2 Sediment Supply**

3503 Very little sediment crosses the U.S.-Canada border because upstream dams trap it. Primary
3504 mechanisms of sediment delivery to the Columbia River Basin between Grand Coulee and
3505 Bonneville Reservoir are landslides and bank erosion that contribute fine-grained sediment that
3506 is mostly transported in suspension (e.g., Alden 1953; Kiver and Stradling 1995; Washington
3507 Division of Geology and Earth Resources 2016a, 2016b; Washington Geological Survey 2017a,
3508 2017b). From Bonneville Reservoir downstream, sediment is largely sourced from volcanic rocks
3509 and is typically coarse grained, contributing to bedload (Whetten, Kelley, and Hanson 1969).
3510 Overall, tributaries that produce the greatest volumes of sediment include the Snake,
3511 Okanogan, Yakima, and Palouse Rivers (Whetten, Kelley, and Hanson 1969). Sediment deposits

3512 in river reaches now occupied by reservoirs are also subject to shoreline erosion. This is
3513 especially true during filling of reservoirs, periods with fluctuating water levels, and reservoir
3514 drawdowns (e.g., Schuster 1979; Cox et al. 2005). Wave energy can cause shoreline erosion
3515 following reservoir filling; however, if reservoir levels are maintained, the shoreline may
3516 eventually approach an equilibrium profile (e.g., Lorang, Komar, and Stanford 1993), decreasing
3517 the sediment yield from shoreline erosion over time.

3518 Sediment supply and transport is affected by dams and flow regulation. Mainstem and tributary
3519 dams trap sediment by changing hydraulic conditions in their impoundments and reducing
3520 sediment supply in downstream river reaches. Flow regulation and the reduction of peak flows
3521 through dam operations further reduce sediment transport capacity. Because sediment
3522 transport capacity is much greater at high flows than low flows, reducing the magnitude of high
3523 flows can reduce the overall capacity of a reach to move sediment. The primary sediment
3524 sources in the Columbia River Basin are incoming sediment load from reaches and tributaries
3525 upstream of a given location, point sources such as landslides and debris flows contributed
3526 from hillslopes along the river and reservoir reaches, and locally eroded sediment from the
3527 channel bed, river banks, reservoir shorelines, and floodplains. However, most of the reaches
3528 evaluated have more than 90 percent of the upstream drainage area affected by upstream
3529 dams, which alters the incoming flow and greatly reduces the incoming sediment supply. A few
3530 exceptions include Hungry Horse Dam (Flathead River), Libby Dam (Kootenai River), and
3531 Dworshak Dam (North Fork Clearwater River) with largely unaltered incoming river flow and
3532 sediment supply due to the relatively pristine conditions of the upper watersheds. Existing
3533 sediment inputs to the reaches are described below to provide context for potential changes in
3534 sediment transport under the No Action Alternative and MOs.

3535 The current average annual sediment load in the Columbia River at Vancouver, Washington, has
3536 been reduced by an estimated 58 percent from pre-1930s conditions (Sherwood et al. 1990).
3537 This reduction in total sediment load is biased toward coarse sediment, with an 80 percent
3538 reduction in sands and a 42 percent reduction in silts and clays from pre-1930s conditions. The
3539 total reduction in sediment load can be attributed to multiple factors including reduction in
3540 peak flows due to system regulation and land use practices, as well as trapping of sediments in
3541 the reservoirs. With an estimated pre-1934 total load at Vancouver at 18.5 million tons per
3542 year, the 241,000-square-mile basin upstream of Vancouver has historically been a low-
3543 sediment-yield basin relative to other major rivers with an average of 77 tons per square mile.
3544 This yield per square mile is 28 percent of the Mississippi River and 7 percent of the Colorado
3545 River suspended load yield, for comparison (Holman 1968).

3546 **3.3.2.3 Storage Reservoirs**

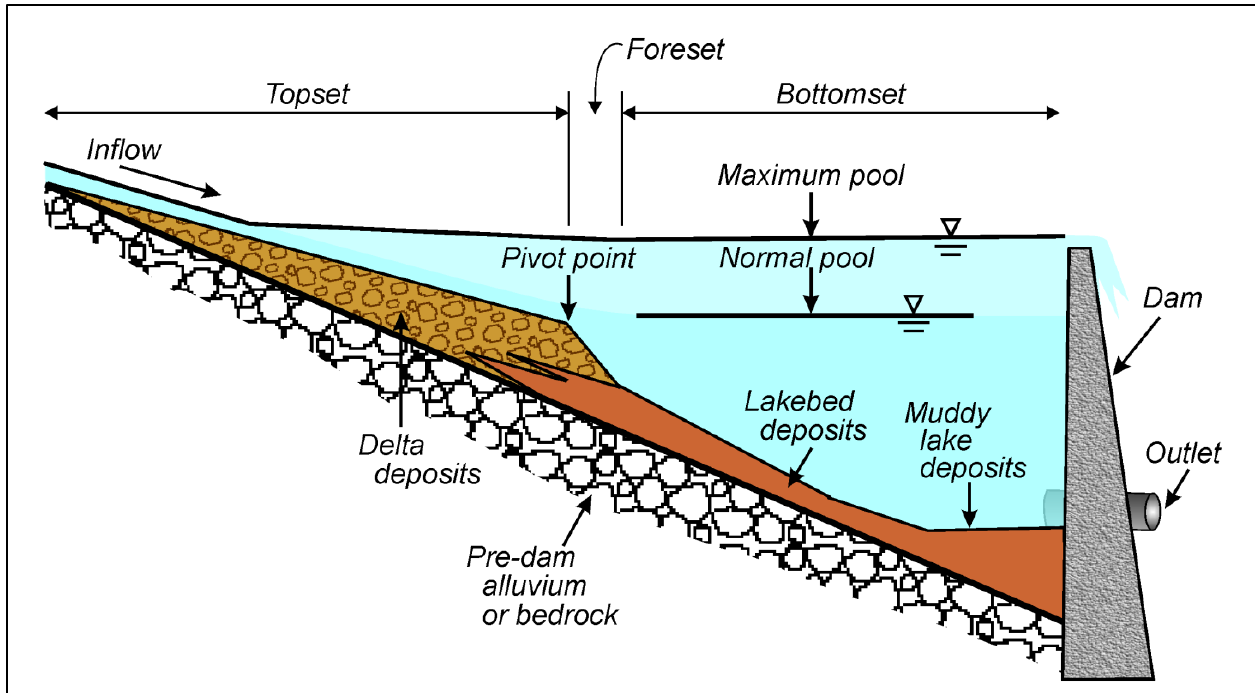
3547 In the CRS, there are six dams that are designed and operated for flood, irrigation, or other
3548 storage purposes: Libby, Hungry Horse, Albeni Falls, Grand Coulee, John Day and Dworshak. In
3549 this analysis, John Day Dam is included in both the storage project and run-of-river categories.
3550 While John Day is authorized for FRM, it has limited storage capacity and is operated more like
3551 a run-of-river project where the project does not store incoming flow. Operators change the

3552 pool elevation at these storage projects over large ranges throughout the year to capture and
3553 release water in specifically designed ways.

3554 **HEAD OF RESERVOIR SEDIMENT MOBILIZATION**

3555 All reservoirs formed by dams on natural watercourses trap some sediment over time. Sand,
3556 gravel, and cobbles entering a reservoir as bedload typically deposit as a delta in the upstream
3557 end of reservoirs and along the upstream river channels as the flow of the river encounters
3558 backwater from the reservoir, slowing velocities and spreading out flow through multiple
3559 channels (Figure 3-104). Sediment deposited in the delta (commonly referred to head of
3560 reservoir deposits) can be remobilized farther downstream when the reservoir operating pool
3561 lowers (during reservoir drawdown), or during floods when sediment transport capacity is
3562 increased. In dams that operate over a wide range of elevations throughout the year, the
3563 upstream extent of reservoir backwater may shift considerable distances. Very fine, suspended
3564 silts and clays tend to transport past the delta and slowly settle out of the water column along
3565 the reservoir bottom as a lakebed deposit. Reservoirs with large storage volumes relative to the
3566 annual volume of water passing through the reservoir tend to trap more suspended sediment
3567 than reservoirs with smaller relative storage volumes.

3568 If reservoir drawdown leaves the delta exposed to riverine conditions during high flow periods,
3569 the upper layers of the delta are often eroded and transported further into the reservoir,
3570 potentially increasing turbidity and downstream sediment deposit thickness. Changes in
3571 storage project elevations or changes to the flow of water and sediment into the reservoir can
3572 result in changes to the delta erosion and deposition patterns. This metric compares the paired
3573 relationships of flow and stage over time to indicate potential for change in sediment
3574 mobilization at the head of reservoir for each alternative. Changes in delta sediment
3575 mobilization could alter the sediment load farther downstream within the reservoir and
3576 potentially the amount of sediment passing a dam, particularly during high flow periods.



3577
3578 **Figure 3-104. Reservoir Sediment Profile with Delta and Lakebed Sediment Deposits**

3579 Note: Reproduced with permission from Randle and Bounry (2017) after Morris and Fan (1997).

3580 **Region A – Libby Dam: Head of Reservoir Sediment Mobilization**

3581 The focal point for deposition within the Libby reservoir (Lake Kootenusa) depends on the
3582 minimum drawdown elevation in the spring before the spring freshet (when 90 percent of the
3583 annual sediment load is mobilized). Since the early 2000s, the minimum pool elevation has
3584 ranged from a low of about 2,370 to a high of 2,420 feet NGVD29 (2,374 to 2,424 feet NAVD88)
3585 in elevation, which correlates to minimum lake backwater extent of RM 280 (near Kragmont,
3586 British Columbia) to RM 300 (4 miles downstream from Wardner, British Columbia). The
3587 maximum pool elevation (2,459 feet NGVD29 [2,463 feet NAVD88]) can extend upstream of
3588 Wardner to the Bull River confluence. Thus, Kootenai(y) River sedimentation (sand and gravel)
3589 in Lake Kootenusa is likely concentrated between Wardner and the Kootenai(y) and Tobacco
3590 River confluence, given that these locations correspond with the maximum and minimum
3591 reservoir elevations. Fine sediment is likely depositing throughout the reservoir but is focused
3592 primarily in the deeper portions of the reservoir near the dam.

3593 **Region A – Hungry Horse: Head of Reservoir Sediment Mobilization**

3594 Little information is available regarding sedimentation in Hungry Horse Reservoir because of a
3595 lack of sediment load data and limited bathymetric survey. A recent bathymetric survey is
3596 available from 2018 that provides a longitudinal profile of Hungry Horse Reservoir with more
3597 detailed survey for the forebay extending about 0.5 mile upstream of the dam (Collins 2020).
3598 There are no large tributaries entering this reach as the reach is closely paralleled by the Swan
3599 Range to the west and the Flathead Range to the east. The majority of flow into the reservoir is
3600 from the upper South Fork Flathead River. One of the larger tributaries entering the reservoir,

3601 Sullivan Creek, has mean annual flows on the order of a few hundred cubic feet per second
3602 (U.S. Geological Survey [USGS] Gage 12361000). The drainage basin is almost all within U.S.
3603 Forest Service land management areas that were historically logged. Based on historical survey
3604 contours of unknown date (provided by Reclamation Pacific Northwest Regional Office, Boise,
3605 Idaho), the minimum pool elevation of 3,426 feet NGVD29 (3,430 feet NAVD88) has a
3606 backwater extent near RM 32 and the maximum pool elevation of 3,560 feet NGVD29 (3,564
3607 feet NAVD88) extends another 9 miles to RM 41. A sediment delta is visible on a September 23,
3608 2003, aerial photograph of the area between RM 38 and at least RM 41. The delta likely extends
3609 farther upstream. The reservoir delta is currently expected to be eroded and mobilized farther
3610 downstream in the reservoir during drawdown and would be expected to continue in No Action
3611 Alternative conditions.

3612 **Region A – Albeni Falls: Head of Reservoir Sediment Mobilization**

3613 The downstream control point of Lake Pend Oreille is Albeni Falls Dam, although there is a
3614 natural restriction near Dover, Idaho at RM 113—roughly 24 miles upstream of the dam—that
3615 can control flow based on lake elevation (velocities in the dam forebay channel can be “river-
3616 like” during high flow conditions). The water surface elevation of the lake may be 6 to 10 feet
3617 higher than that of the forebay due to the natural channel restriction at the lake outlet. The
3618 head of the reservoir is effectively the 4-mile-long Clark Fork River Delta, including the mouth of
3619 Lightning Creek. Lake level influences the velocity, depth, and general hydraulic conditions up
3620 to about a mile above Lightning Creek.

3621 Rain-on-snow events and spring runoff have the potential to move tremendous amounts of bed
3622 load in tributaries of the Clark Fork River, but especially in the Lightning Creek drainage. A large
3623 alluvial gravel deposit has developed in the mainstem of the Clark Fork River in the floodplain of
3624 Lightning Creek, just upstream of the Clark Fork River Delta. The gravel bar includes a layer of
3625 gravels and sands deposited in the area by Lake Missoula, but now also hosts the thick gravel
3626 fragments and coarse cobbles of the Lightning Creek alluvial deposit.

3627 The Lake Pend Oreille delta is composed of fine-grain sediments deposited in slackwater by the
3628 low-gradient Clark Fork River. The delta has likely been depositing since its formation, but the
3629 process likely accelerated following completion of the dam. The reduction in available sediment
3630 bedload within the Clark Fork River following completion of the upstream dams (Cabinet Gorge
3631 and Noxon Rapids) has also likely contributed. The bedload coming out of Lightning Creek is
3632 relatively high and dominantly comprised of large gravels and cobbles which ultimately settle at
3633 the Clark Fork River confluence due to the abrupt decrease in gradient between the creek and
3634 river.

3635 **Region B – Grand Coulee: Head of Reservoir Sediment Mobilization**

3636 Much of the sediment that would enter this reach from upstream is trapped by reservoirs in
3637 Canada, including behind four large hydroelectric dams. The reach of the Columbia River
3638 between the U.S.-Canada border and Grand Coulee Dam is naturally a bedrock-controlled river,
3639 lacking a thick alluvial cover (Whetten, Kelley, and Hanson 1969).

3640 The mainstem Columbia River profile measured in 2010 and 2011 includes numerous pools
3641 between the U.S.-Canada border and Grand Coulee Dam that range in depth from 20 to more
3642 than 100 feet. The first 40 miles upstream of the dam contain several scour pools 30 to 40 feet
3643 deeper than the typical reservoir bottom, which indicates sediment supply has not been large
3644 enough to fill in the pools. The maximum reservoir pool extends upstream approximately 150
3645 miles from the dam at RM 596 to about RM 746 based on 2010 topography. The minimum pool
3646 extends 121 miles upstream from the dam to about RM 717. Any sediment delta present
3647 between RM 717 and RM 746 could be eroded during reservoir drawdown operations.
3648 However, in this reach there was no sediment delta present, and several pools persist that are
3649 tens of feet deep, indicating sediment deposits are likely limited to partially filling pools and on
3650 floodplains when inundated at higher reservoir elevations. Two of the largest pools are more
3651 than 140 feet deep located near the confluences of the Columbia River with Onion Creek (RM
3652 733.6) and the Kettle River (RM 709). The persistence of the deep pools means that either there
3653 are fast velocities along the reservoir bottom at these locations or the reservoir sedimentation
3654 rates are slow.

3655 Sediment deltas can also form where tributaries enter the backwater from Lake Roosevelt. The
3656 first major tributary upstream of the dam is the Sanpoil River (RM 615) where Lake Roosevelt
3657 inundates about 9 miles of the tributary at full pool. The difference between maximum and
3658 minimum pool is 2 miles long where there is potential to mobilize any sediment deposited from
3659 the Sanpoil River Basin. Within Lake Roosevelt, the largest tributary is the Spokane River (total
3660 drainage area of 6,750 square miles), which begins at the outlet of Lake Coeur d'Alene, Idaho,
3661 and enters the Columbia River at RM 640 about 44 miles upstream of Grand Coulee Dam. The
3662 Spokane River contributes the largest amounts of suspended sediment to Lake Roosevelt
3663 (Whetten, Kelley, and Hanson 1969), but coarse sediment contributions that would tend to
3664 form a sediment delta are limited. Seven hydroelectric dams have been constructed on the
3665 mainstem Spokane River between 1890 and 1922 (Northwest Power and Conservation Council
3666 [NW Council] 2019c). Based on topographic intersection of reservoir pool elevations measured
3667 in 1974 (5-foot contours), the backwater from Lake Roosevelt extends about 18.5 miles
3668 upstream at minimum pool and 32 miles upstream at full pool (Ferrari 2012). Aerial
3669 photography from 1936 (after construction of the seven Spokane River dams) and recent aerial
3670 photography (1992 to 2017) do not show any exposed sediment delta downstream of Little
3671 Falls Dam. Further, the 2010–2011 survey measured several scour pools around 20 feet in
3672 depth (Ferrari 2012). The lack of visible sediment delta may be due to limited sediment supply
3673 due to trapping in upstream Lake Coeur d'Alene and behind the seven dams. There are several
3674 landslides along the Lake Roosevelt Arm of the Spokane River. A major landslide deposited
3675 more than 60 feet of eroded material above the original river channel area at RM 3.7. However,
3676 the landslide deposit is 40 feet below the minimum pool so it would not be expected to have
3677 any mobilization due to reservoir drawdown.

3678 Lake Roosevelt creates about a 1.5-mile backwater up the Colville River, which enters the
3679 Columbia River near RM 702.4. The difference in maximum and minimum pool exposes about 1
3680 mile of river that could create a sediment delta subject to erosion during reservoir drawdown. A
3681 larger tributary is the Kettle River, which enters near RM 709 on the mainstem Columbia River.

3682 The 2010–2011 survey went about 3.5 river miles upstream on Kettle River near Kettle Falls.
3683 The maximum pool extends about 8 miles upstream on the Kettle River, and the minimum pool
3684 drops all the way to the Kettle River confluence with the Columbia River. Reservoir drawdown
3685 does have the potential to mobilize any deposited sediment from Kettle River incoming
3686 sediment loads. Upstream of Kettle Falls the reservoir does not create a substantial backwater
3687 pool in any tributaries.

3688 Since the late 1800s, large amounts of slag have been released into the upper Columbia River
3689 from an upstream smelter operation. Because Lake Roosevelt has a high sediment trapping
3690 efficiency, much of the incoming slag has been retained within Lake Roosevelt, particularly in
3691 the upstream reaches (Teck 2017). As a result, bed and bank sediments in Lake Roosevelt
3692 contain elevated metals.

3693 **Region C – Dworshak: Head of Reservoir Sediment Mobilization**

3694 Dworshak Reservoir lies within narrow, steep canyons of the North Fork Clearwater River.
3695 Dworshak Dam traps sediment from 26 percent of the Clearwater River drainage basin (which is
3696 2 percent of the Snake River drainage area). The reservoir extends approximately 51 miles
3697 upstream of the dam at full pool elevation. The drainage area upstream of the dam is
3698 topographically rugged, densely timbered, sparsely populated, and largely undeveloped with a
3699 total area of approximately 2,440 square miles (Corps 1986). The reservoir is drawn down
3700 during the winter to provide storage space for FRM.

3701 Note that Dworshak Reservoir is the only reservoir in Region C operated for storage; the
3702 remaining reservoirs in Region C are run-of-river reservoirs. Sediment mobilization at the head
3703 of run-of-river reservoirs was computed separately via the “Potential for Bed Material Change
3704 Metric.” Discussion of the head of reservoir sedimentation for Lower Granite Reservoir is
3705 presented in Section 3.3.2.4, below.

3706 **Region D – John Day: Head of Reservoir Sediment Mobilization**

3707 Unlike the other CRS storage reservoirs, John Day was constructed with navigation as a primary
3708 purpose. The project provides for minimum depth of 15 feet of water between John Day and
3709 McNary Dams. Due to this design requirement, and sediment trapping in upstream dams, there
3710 is no traditional head of reservoir delta or deposition occurring in the mainstem Columbia River
3711 in the John Day Reservoir.

3712 **SEDIMENT TRAP EFFICIENCY**

3713 All the reservoirs in the study area can trap a portion of the material that enters their pools,
3714 reducing the incoming sediment to downstream reservoirs. Trap efficiency is the proportion of
3715 inflowing sediment deposited in the reservoir relative to the total incoming sediment load. The
3716 trap efficiency is computed based on the ratio of reservoir storage volume to annual inflow.
3717 Reservoirs with high trap efficiency generally trap the coarse sediment in reservoir deltas, while
3718 a portion of the fine sediment can be transported through the reservoir and released

3719 downstream. The actual amount of sediment trapped is dependent not only on trap efficiency
3720 but also the incoming sediment load.

3721 A trap efficiency less than 10 percent indicates very little sediment has accumulated in a
3722 reservoir, whereas a trap efficiency greater than 90 percent indicates potential for a large
3723 accumulation of reservoir sediment. John Day traps the least amount of sediment (44.9
3724 percent) amongst the storage projects, which can be attributed to its small reservoir volume
3725 relative to the annual hydrograph. Albeni Falls (70.6 percent) and Grand Coulee (77.8 percent)
3726 trap approximately three-quarters of incoming sediment. Libby (90.7 percent), Hungry Horse
3727 (95.0 percent), and Dworshak (93.0 percent) have the highest sediment trap efficiencies.

3728 **Region A – Libby Dam: Sediment Trap Efficiency**

3729 Based on the sediment flux (total tons transported per year) measured in the 1960s near Libby
3730 Dam, it was estimated that 100,000 acre-feet of sediment would be trapped in Lake Koochanusa
3731 over a period of 100 years (Corps 1971). The volume of sediment that this represents over a
3732 100-year period equates to about 2 percent of the 5-Maf total reservoir active flood control
3733 space (Corps 1971). By comparing the pre- and post-dam average annual sediment loads at the
3734 Libby and Copeland stations, the annual average sediment deposition can be estimated. Data
3735 confirms the 1971 estimate of 1,000 acre-feet per year and estimates that Libby Dam could
3736 accumulate about 31,000 acre-feet of sediment (suspended load, plus 10 percent for bedload)
3737 in a 30-year period.

3738 **Region A – Hungry Horse Dam: Sediment Trap Efficiency**

3739 While not much is known about reservoir sedimentation in Hungry Horse, it has a high trapping
3740 efficiency for sediment delivery from the 1,168-square-mile South Fork Flathead River
3741 catchment that prevents the majority of incoming sediment from going downstream past the
3742 dam to the main stem Flathead River.

3743 **Region A – Albeni Falls Dam: Sediment Trap Efficiency**

3744 Lake Pend Oreille, at more than 1,000 feet deep in some locations, acts as a natural sediment
3745 sink upstream of Albeni Falls Dam. The sediment trap efficiency is relatively high (70-plus
3746 percent), and it is responsible for reduced sediment supply conditions downstream along the
3747 lower Pend Oreille River.

3748 **Region B – Grand Coulee Dam: Sediment Trap Efficiency**

3749 The historical Columbia River channel within Lake Roosevelt is governed by the underlying
3750 bedrock because the riverbed does not have a deep layer of alluvium. Within the reservoir
3751 (Lake Roosevelt), substantial alluvial deposits are widely spaced and generally small in volume
3752 in both the riverine and lacustrine reaches of the reservoir (Ferrari 2012). The sediments that
3753 do accumulate in Lake Roosevelt consist of armored gravels between the U.S-Canada border
3754 and Onion Creek, which can become riverine during minimal pool conditions. Farther

3755 downstream, the river bed is primarily silt and clay in the middle and lower Lake Roosevelt
3756 (lacustrine) reaches (Whetten, Kelley, and Hanson 1969; Windward Environmental LLC 2017).

3757 **Region C – Dworshak Dam: Sediment Trap Efficiency**

3758 Sediment range lines have been surveyed in Dworshak Reservoir to measure sediment
3759 deposition, but the survey measurements are not reported here because the accuracy could
3760 not be verified; Dworshak Reservoir can exceed 600 feet in depth and is thermally stratified,
3761 making precise acoustic measurements highly sensitive to depth-varying calibration of the
3762 speed of sound. The Dworshak water control manual (Corps 1986) estimated an average annual
3763 sediment load on the order of 300 acre-feet per year, based on measurements of other streams
3764 in the region. Since the time of that estimate, limited sediment load measurements have been
3765 taken on the North Fork Clearwater River upstream of Dworshak and on two tributaries of the
3766 South Fork Clearwater River, which seem to support the argument made in the water control
3767 manual that the north fork is like other streams in the region. However, these measurements
3768 were taken during the spring season, and therefore would not have included mass wasting
3769 during large winter floods, which have the potential to exceed spring sediment loads. The
3770 estimate provided in the water control manual is higher than current sediment load estimates
3771 for the entire Clearwater River and is the only available estimate at this time. If the 300 acre-
3772 foot estimate is reasonable, it could take more than 2,500 years to accumulate a volume of
3773 sediment equal to the dead storage space in Dworshak Reservoir. However, this is an order of
3774 magnitude estimate and could therefore be conservatively reported as 250 to 2,500 years. In
3775 either case, the sediment load appears to be relatively small compared to the storage volume.

3776 **Region D – John Day Dam: Sediment Trap Efficiency**

3777 The most recent assessment of sediment deposition and bed material composition in the John
3778 Day Reservoir was completed by USGS (Cross and Twichell 2004). Geophysical survey data
3779 collected in 2000 and ground-validation data collected in 2000 and 2002 revealed that reservoir
3780 had lost approximately 0.2 percent of its volume since construction. Data analysis indicated
3781 that the reservoir bottom consists of 23 percent exposed basalt, 5 percent boulders, 9 percent
3782 fine-grained sediment with an estimated thickness of 20 inches, and 53 percent shallow
3783 discontinuous veneer of fine-grained sediment. This thin veneer covers historical bars, gravel
3784 beds, alluvial fans, and other unconsolidated deposits. The upstream-most 12.5 to 15.5 miles of
3785 reservoir, representing 10 percent of the total reservoir floor, showed gravel beds completely
3786 free of fine sediment.

3787 **SHORELINE EXPOSURE**

3788 Wave erosion, reservoir currents, freeze-thaw, reservoir drawdown, and other processes can
3789 result in shoreline erosion of bank sediments along the reservoir margins.

3790 Region A – Libby Dam: Shoreline Exposure

3791 During the design of Libby Dam, the Corps assumed that far less sediment would enter the
3792 reservoir from mass wasting and shoreline erosion than from the river itself (Corps 1971). Corps
3793 review of available aerial imagery showed that extensive shallow landslides along the 224-mile-
3794 long shoreline has occurred around the reservoir and that few large slides were evident. No
3795 subsequent estimates of reservoir sedimentation were available to assess if the amount of
3796 shoreline erosion that has occurred since the construction of Libby Dam is in line with
3797 predictions made during earlier design efforts. It is thought that in the first decades after
3798 reservoir filling, reservoir erosion rates were likely higher than under current conditions
3799 because more than four decades have elapsed since construction allowing for the reservoir
3800 side-slopes to erode back to stable conditions.

3801 Region A – Hungry Horse Dam: Shoreline Exposure

3802 Hungry Horse Reservoir has approximately 175 miles of shoreline with little available
3803 documentation on shoreline erosion. Most of the surrounding landscape contains forested
3804 hillslopes, but areas subject to reservoir drawdown may experience erosion. A prior Columbia
3805 River System Operation Review EIS (DOE, Corps, Reclamation 1995) noted that “Hungry Horse
3806 Reservoir exhibits significant shoreline erosion in its upstream reaches, as well as several large,
3807 active landslides.” The magnitude of erosion is not known.

3808 Region A – Albeni Falls Dam: Shoreline Exposure

3809 Lake Pend Oreille has a seasonal variable operating range of about 11 feet as regulated by
3810 Albeni Falls Dam, which has caused lateral shoreline erosion of the delta at a rate of about 5 to
3811 8 feet per year for the last 50-plus years (Clark Fork Delta Restoration 2018). The Clark Fork
3812 River delta at the east end of the lake is not the only area around Lake Pend Oreille with
3813 eroding shorelines. Receding protective and stabilizing shorelines and islands at the mouths of
3814 streams and rivers have seen accelerated erosion caused by wave action, landslides, and river
3815 flows. Additional sites in the subbasin where ongoing erosion is of concern include the Pack
3816 River Delta, Strong’s Island, and the mouths of Priest River, Hoodoo Creek, Hornby Creek, and
3817 Carr Creek (Idaho Department of Environmental Quality [IDEQ] 2007). Overall, the riverbank
3818 conditions of the Pend Oreille River above Albeni Falls are highly susceptible to erosion where
3819 the banks do not consist of bedrock or large boulders (Tri-State Water Quality Council 2005).

3820 Region B – Grand Coulee Dam: Shoreline Exposure

3821 Landslides are an important source of sediment along the Lake Roosevelt shoreline. Some
3822 landslides along the Columbia River within Lake Roosevelt existed before the construction of
3823 Grand Coulee Dam and are a few hundred to a few thousand years old (Pardee 1918; Kiver and
3824 Stradling 1995); other landslides appear to have been associated with destabilization of the
3825 landscape during glaciation (Flint and Irwin 1939; Jones et al. 1961). More than 500 landslides
3826 also formed along the shoreline of Lake Roosevelt in response to the filling of the reservoir and
3827 fluctuating water level (Cox et al. 2005).

3828 **Region C – Dworshak Dam: Shoreline Exposure**

3829 Dworshak Reservoir’s shoreline is approximately 175 miles at full pool (Corps 1986). The widest
3830 sections of the reservoir are in the lower one-third of its length, where the widths range
3831 generally from about 0.5 to 1 mile, with the widest point being nearly 2 miles. The upper two-
3832 thirds of the reservoir is much narrower, ranging mostly between 1,000 and 2,000 feet. The
3833 lake water surface elevation can fluctuate up to 155 feet due to Dworshak Dam flood risk
3834 operations, but during lower risk years, the water surface is only drawn down 80 feet below full
3835 pool. Bank erosion or sloughing resulting from fluctuations in pool elevation is not known to be
3836 a serious issue.

3837 **Region D – John Day Dam: Shoreline Exposure**

3838 There are deep-seated landslides in the vicinity of John Day Dam and reservoir. Most mass
3839 wasting has occurred on the Washington shore. A landslide on the Washington shore was
3840 reactivated during dam construction but appears stable now. Most of the shoreline is not being
3841 significantly eroded, and riprap protection seems to be adequate for lower pool operation
3842 (Gustafson 1992).

3843 **3.3.2.4 Run-of-River Reservoirs and Free-Flowing Reaches**

3844 Run-of-river reservoirs and free-flowing reaches include all the river reaches downstream of
3845 CRS storage projects. Run-of-river reservoirs are formed by dams that are operated to discharge
3846 water downstream at rates that generally match the upstream inflows. The effect on river
3847 discharge from dam operations is generally smaller for run-of-river reservoirs than storage
3848 reservoirs. Bonneville Dam is an example of a run-of-river project that operates in a small range
3849 of pool elevations for daily or weekly hydropower purposes but does not attempt to store
3850 water for release in later seasons. There are nine CRS run-of-river reservoirs. Region B includes
3851 Chief Joseph at RM 545.7. Region C includes Lower Granite (RM 430.9), Little Goose (RM 393.8),
3852 Lower Monumental (RM 365.0), and Ice Harbor (RM 333.4) on the Lower Snake River. Region D
3853 on the Lower Columbia River includes McNary (RM 291.0), John Day (RM 216.6), The Dalles (RM
3854 192.0), and Bonneville Dam (RM 145.7). Note that John Day Dam generally operates as a run-of-
3855 river project even though there is a small amount of storage, and thus is included in both
3856 categories. Five non-CRS run-of-river reservoirs exist in Region A and another five exist in
3857 Region B.

3858 Free-flowing reaches are portions of the river that are not influenced by the backwater of a
3859 downstream reservoir. Free-flowing reaches experience altered hydrology where upstream
3860 dam operations have an influence on changing river discharge. The altered hydrology can affect
3861 floodplain connectivity, river morphology, and sediment transport capacity. Free-flowing
3862 reaches in Region A include the Kootenai River between Libby Dam and Bonners Ferry, Idaho,
3863 the Flathead River downstream of Hungry Horse Dam and upstream of Flathead Lake, and the
3864 Clark Fork River between SKQ Dam and Thompson Falls Reservoir. Other notable free-flowing
3865 reaches in the study area include the Northport Reach of the Columbia River upstream of Kettle
3866 Falls and the Hanford Reach of the Columbia River downstream of Priest Rapids Dam (Region

3867 B), the Clearwater River between Dworshak Dam and Lower Granite Reservoir (Region C), and
3868 the tidal Columbia River downstream of Bonneville Dam (downstream Region D).

3869 **SEDIMENT TRANSPORT AND SUPPLY.**

3870 Unlike the large storage projects, nearly all the run-of-river reservoirs have a small volume of
3871 water in their pools relative to the volume of annual water flow. This results in lower trapping
3872 efficiencies than the large storage projects. In addition to the decreased ability of the run-of
3873 river reservoirs to trap sediment, the upstream sediment load is reduced because of upstream
3874 reservoirs.

3875 Free-flowing reaches are operating in a reduced sediment environment from their historical
3876 unregulated (pre-1930s) condition because of cumulative trapping of sediment in upstream
3877 reservoirs. These reaches commonly pass the reduced incoming sediment load and have
3878 developed coarsened bed conditions, some of which are naturally armored against erosion.

3879 Bed-material load consisting of sands and gravels entering run-of-river reservoirs and free-
3880 flowing reaches from tributaries and other processes such as localized erosion can deposit on
3881 the beds and be permanently stored in the system. Given the variability in size and nature of
3882 tributaries flowing into the study area, the amount of sediment delivered and stored at each
3883 tributary may be negligibly small or quite sizable. The Salmon River (via the Snake River) and
3884 Clearwater River sediment delivery to Lower Granite Reservoir on the Snake River is an example
3885 of a large tributary sediment supply that deposits a large volume of sediment annually.

3886 **Region A – Kootenai River Sediment**

3887 Glaciation on the Kootenai River during the ice ages is responsible for carving deep valleys now
3888 occupied by lakes and rivers over long and short time periods, storing large quantities of
3889 unconsolidated sediment in the basin valleys. When the ice sheet and associated glacial lake
3890 receded, the steep, rejuvenated rivers and streams widened their valleys, transporting large
3891 volumes of sediment downstream. In some places, the Kootenai River has cut through the
3892 glacial sediments into the underlying bedrock. Bedrock is exposed in the riverbed near the
3893 Fisher River, in the Kootenai Falls area, and near Troy, Montana. It is also exposed in riverbanks
3894 and bottomlands near Bonners Ferry, Idaho.

3895 The bedrock sill at the outlet of the West Arm of Kootenay Lake arrested down-cutting. It is
3896 likely that post-glacial Kootenay Lake originally extended south along the Purcell Trench nearly
3897 to Bonners Ferry, but it was gradually filled with hundreds of feet of fine sediment eroded from
3898 up valley so that the lake was gradually converted into a floodplain (Alden 1953).

3899 The Kootenai River downstream of Libby Dam is free flowing for approximately 61 miles, after
3900 which it becomes progressively less able to transport sediment due to backwater influences
3901 from Kootenay Lake located north of the U.S.-Canada border. In a 6-mile reach known as the
3902 “Braided Reach” immediately above Bonners Ferry, the river can pass sediment sizes up to
3903 gravels. Downstream of Bonners Ferry, sand silt and clay become the dominant material in

3904 transport with little gravel passing into the downstream reach known as the “Meander Reach.”
3905 Due to the Kootenay Lake backwater, the 45-mile long Meander Reach is the least-efficient
3906 reach at passing sediment in U.S. waters below Kootenai Falls, passing fine sand and smaller
3907 grain sizes downstream.

3908 Below Libby Dam, tributaries supply large quantities of gravel- and cobble-sized materials at
3909 rates greater than the rates the mainstem river can erode them, resulting in the formation of
3910 alluvial fan deposits. Because these locations constrict the river, they tend to transport all but
3911 the largest-sized sediment that enter from upstream. The largest-sized sediment from steeper
3912 tributaries is often found in tributary fans that persist despite high flows from the river (e.g., at
3913 the Fisher River, Yaak River, and Boulder Creek confluences). Cobble, gravel, and sand sized
3914 sediments that make it into the reaches upstream of Bonners Ferry can be transported by the
3915 river downstream to the Braided Reach; however, much of this material is too large to be
3916 transported very far downstream. Thus, the Braided Reach is a sink for gravel and coarser-sized
3917 sediment supplied by the river upstream.

3918 Downstream of Libby Dam to Bonners Ferry, the percentage of sand within the exposed bars
3919 increases with distance from the dam because of unregulated tributary inputs. The percentage
3920 of the bed composed of sand increases dramatically in the critical Kootenai River white
3921 sturgeon spawning reach, where the Braided Reach transitions into the Meander Reach
3922 (Barton, McDonald, and Nelson 2009; Fosness and Williams 2009; McDonald et al. 2010).
3923 Previous research (Barton, McDonald, and Nelson 2009; McDonald et al. 2010) has determined
3924 that the Kootenai River white sturgeon spawning reach substrate is sand dominated now, but
3925 that this is an artifact of the reduction in peak discharges as the pre-dam high flows were
3926 routinely capable of scouring sand and exposing coarser lag deposits of gravel and cobble
3927 suitable for spawning. The researchers found that the post-dam hydrologic regime, under the
3928 highest post-dam flows, can still scour sand from these spawning areas (Fosness and Williams
3929 2009; McDonald et al. 2010), but this occurs much less frequently than under pre-dam
3930 conditions.

3931 **Region A – Flathead, Clark Fork, and Pend Oreille Rivers Sediment**

3932 Even before the completion of SKQ Dam, the naturally occurring Flathead Lake and delta
3933 functioned as a sediment trap for the downstream Flathead River. Joyce (1980) concluded that
3934 Flathead Lake had been accumulating roughly 0.55 inches per year of sediment since the 1964
3935 flood of record. The largest sources of sediment within the study reach exist in the thick
3936 Quaternary (a recent period of geologic time spanning from 2.58 million years ago until today
3937 that was marked by the advance and retreat of glaciations, greatly sculpting the landscape
3938 morphology) deposits within Flathead Valley, upstream of Flathead Lake. Shorelines of Flathead
3939 Lake provide an additional source of sediment; however, this source is not as substantial, as
3940 Flathead Lake receives more than 90 percent of its sediment from the Flathead River (Moore,
3941 Jiwan, and Murray 1982). Sediment from upstream and eroded from Flathead Lake is likely
3942 trapped within the lake, rather than traveling downstream.

3943 Downstream of the Hungry Horse Reservoir in the South Fork Flathead, Alden (1953) notes that
3944 till (glacially transported sediment that is typically poorly sorted) and gravel have been largely
3945 eroded from many locations, allowing the river to cut bedrock gorges, leaving terraces of
3946 Quaternary gravels bordering the river in some locations.

3947 The Flathead River below the confluence with the South Fork Flathead River is an active,
3948 anastomosing river (a river planform type where multiple channels are separated by stable mid-
3949 channel islands commonly associated with flood regimes) within a massive valley. The
3950 undammed North and Middle Forks of the Flathead River are a sediment source, and large
3951 amounts of sediment and wood are associated with a large peak flow. Deposition of debris that
3952 fills a channel, or flood flows that occupy alternative channel routes with steeper paths, are
3953 both potential risks for channel avulsions (the process of a river channel changing its planform
3954 by abandoning its previous path in favor of another channel path; this can result in the creation
3955 of a new channel or the shifting of flow to a side channel or previously abandoned channel
3956 path). In part because Flathead Lake controls the river's base level, there has also been
3957 substantial re-working, rather than removal, of these deposits within the basin (Smith 2004).

3958 The natural sink of the deep Flathead Lake and the regulated operations of SKQ Dam make for a
3959 sediment-starved lower Flathead River. Downstream of SKQ Dam, Lake Pend Oreille is an
3960 efficient natural sediment sink in the Flathead, Clark Fork, and Pend Oreille Rivers. Between
3961 SKQ Dam and Albeni Falls, Noxon Rapids Dam traps the highest percentage of inflowing
3962 sediment. Downstream of Albeni Falls, the Slate Creek to Boundary Dam reach traps the highest
3963 percentage of inflowing sediment.

3964 The Clark Fork River subbasin is prone to rapid runoff events; however, system wide flow
3965 regulation has curtailed this phenomenon. Glacial fluvial deposits are present in the valley, river
3966 banks, and on mountainside slopes. The highly erosive sediments have worked their way
3967 through the Clark Fork River System in infrequent flood pulses, such as 1948 and 1997, while
3968 conversely getting trapped behind hydroelectric dam projects during low- to moderate-
3969 hydrologic years.

3970 Following the construction of Albeni Falls Dam, the lake has been held at a higher-than-natural
3971 condition and operated over a range of 11 feet. While the Clark Fork River contributes
3972 approximately 92 percent of the annual inflow to Lake Pend Oreille (IDEQ 2007), most of the
3973 annual suspended sediment load is contributed from Lightning Creek. Lightning Creek gradient
3974 and channel incision make for fairly unstable banks that are prone to naturally occurring mass
3975 failures (U.S. Department of Agriculture [USDA] 2015). A recent sediment model estimated a
3976 delivery to the Clark Fork River via Lightning Creek of more than 4,100 tons of sediment per
3977 year (IDEQ 2007). The majority of large gravels, cobbles, and boulders it transports to the river
3978 settle at the confluence because of the extreme decrease in grade from Lightning Creek to the
3979 river. The Clark Fork River Delta is an important sediment depositional zone.

3980 The Pend Oreille River channel substrate above Albeni Falls Dam is dominated by granitic type
3981 sands and silt with areas of embedded heavy woody organic debris that is derived from
3982 catchments below Cabinet Gorge Dam. Although some recent substrate sampling work was

3983 somewhat limited in scope, very little gravel was found on the river bottom, and the gravel that
3984 was encountered was buried within sand and silt.

3985 Box Canyon Dam likely traps coarse sediments brought in by tributaries or bank erosion.
3986 Downstream of Box Canyon Dam, the reservoir behind Boundary Dam becomes a substantial
3987 sink of bed material and some suspended sediment. Clay deposits appear in the Boundary Dam
3988 forebay, though most all of it passes through the project, according to a sediment model built
3989 for 2009 sedimentation study (Fullerton et al. 2009). Approximately one-quarter of the silt is
3990 trapped in the reservoir, and nearly 100 percent of the bed material load is trapped. The clay
3991 fractions represent on average approximately 20 percent of the forebay samples, with silt
3992 comprising most of the remaining material.

3993 **Region B – Middle Columbia River Sediment**

3994 Below Grand Coulee Dam, tributaries are an important source of sediment and alluvial fans
3995 exist near the junctions with many tributaries. Landslides also exist along shorelines below
3996 Grand Coulee Dam, providing sediment to these reaches. Suspended sediment concentrations
3997 in the upper Columbia River are typically low; the greatest amounts of suspended sediment are
3998 sourced from the Okanogan River. During high flow events, suspended sediment can pass
3999 through structures to downstream reaches; otherwise, suspended sediment is trapped by
4000 reservoirs.

4001 From Grand Coulee Dam to Priest Rapids Dam, bed material is dominated by thin deposits of
4002 gravel and sand over bedrock. Generally, the grain size of reservoir deposits increases with
4003 distance upstream of the dams in each reservoir (Kelley and Whetten 1961; Whetten, Kelley,
4004 and Hanson 1969).

4005 Below Priest Rapids Dam, the free-flowing Hanford Reach composition is largely sand, gravel,
4006 and cobbles up to 8 inches in diameter, with small fractions of silt and clay in lower-velocity
4007 deposition areas (Jamison 1982).

4008 **Region C – Lower Snake River Sediment**

4009 Sediment yield to the lower Snake River is derived from three major basins: upper Snake River,
4010 Clearwater River, and Salmon River. Sediment contributions to the Snake River from upstream
4011 of Hells Canyon Dam are effectively trapped by the Hells Canyon Complex (Hells Canyon Dam,
4012 along with upstream Oxbow and Brownlee Dams), and are essentially small enough to be
4013 considered negligible. The North Fork of the Clearwater River is regulated by Dworshak Dam,
4014 which retains all sediment upstream. The remaining Clearwater Tributaries (Lochsa, Selway,
4015 South Fork Clearwater, Potlatch River, and Lapwai Creek) comprise about 10 percent of the
4016 lower Snake River sediment load on average. Downstream of Hells Canyon Dam, the Salmon
4017 River sediment yield averages about two-thirds of the lower Snake River sediment load.
4018 Downstream of these confluences, the Snake River at Anatone, Washington, comprises about
4019 90 percent of the sediment load to the lower Snake River (PSMP, Corps 2014c).

4020 The deep run-of-river reservoirs of the four lower Snake River dams have the least ability to
4021 transport sediment of all reaches between the Columbia River and Dworshak Dam. While the
4022 four reservoirs have similar characteristics, the upstream reservoir, Lower Granite, receives a

4023 substantially larger sediment load originating in the free-flowing Salmon River, upper
4024 Clearwater River, and other smaller tributaries. Lower Granite only passes clay and silt-sized
4025 material up to coarse silt, which is largely capable of passing through the lower three Snake
4026 River Dams to McNary Reservoir.

4027 Lower Granite Reservoir continues to be a depositional zone for Clearwater and Snake River
4028 sands and silts. Coarse sediment (median particle diameter by mass, d_{50} , of medium sand)
4029 settles out first near the upstream end of the reservoir, followed by finer sediment moving
4030 downstream (d_{50} approaching very fine silt at Lower Granite Dam). Suspended sediments
4031 passing Lower Granite Dam largely pass through the remainder of the downstream Snake River
4032 dams. Bed material in the lower three reservoirs range from a d_{50} of medium sand to fine silt
4033 with Ice Harbor Reservoir sediment being coarsest and Lower Monumental Reservoir sediment
4034 being finest. Sediment deposition in the Snake River is managed per the Lower Snake River
4035 Programmatic Sediment Management Plan (PSMP) (Corps 2014c). The PSMP is the sediment
4036 management strategy for the lower Snake River system extending from the Snake River
4037 confluence with the Columbia River to the upstream limits of Lower Granite Reservoir, including
4038 the lower portion of the Clearwater River. The management measures fall within four general
4039 categories: dredging and dredged material management, structural management, system
4040 management, and upland sediment reduction. The PSMP does not attempt to address all
4041 sediment deposition in the lower Snake River. It addresses only sediment that interferes with
4042 existing authorized project purposes of the lower Snake River Projects.

4043 ***Region C – Lower Snake River Navigation Sedimentation***

4044 Sediment accumulates in areas where it impacts navigation or other authorized purposes in the
4045 lower Snake River System. Sediment management is conducted in these areas in conformance
4046 with the PSMP. The PSMP is the Corps' adaptive management plan for maintenance actions
4047 managing sediment accumulation in the lower Snake River Projects (Corps 2014c). According to
4048 the PSMP, "Approximately 80 percent of the volume of material historically dredged from the
4049 LSRP [lower Snake River Projects] system has come from Lower Granite Reservoir." The primary
4050 area of concern for recurring immediate actions is near the confluence of the Snake and
4051 Clearwater Rivers, which is at the upstream end of the Lower Granite Reservoir. The navigation
4052 channel can be dredged on an as-needed basis to the federally authorized depth of 14 feet at
4053 MOP. The dredged material may be placed in-water (sometimes to create beneficial shallow-
4054 water habitat for juvenile salmonids and other species) or upland.

4055 **Region D – Lower Columbia River Sediment**

4056 Bed material in the Columbia River at the Snake River confluence has an observed d_{50} of fine
4057 sand. The bed material becomes finer going downstream with a d_{50} of medium silt in the 25
4058 miles of reservoir immediately upstream of McNary Dam. The McNary Reservoir receives
4059 sediment from multiple tributaries including the mainstem Columbia, Yakima, Snake, and Walla
4060 Walla Rivers. Sand-sized and larger sediments, as well as some silts, deposit in the reservoir
4061 below the Snake River confluence with the Columbia River, and only clays and silts are capable
4062 of passing McNary Dam.

4063 Downstream of McNary, the lower John Day Reservoir has the lowest ability of any subreach to
4064 transport coarse sediment. While John Day Dam is a CRS storage project, the reservoir more
4065 resembles the mainstem Columbia River run-of-river reservoirs in how upstream sediment
4066 loads are supplied and transported through. Despite John Day's low ability to transport
4067 sediment relative to the downstream reaches, the upstream sediment supply is primarily silt,
4068 which largely passes through John Day Reservoir. The lower Columbia Dams do effectively trap
4069 the coarse Cascade Range tributary sediments with only medium to fine silt and clay passing
4070 Bonneville Dam. Sediments capable of passing Bonneville Dam transport all the way to the
4071 Columbia River estuary and Continental Shelf.

4072 Bed material sediments (sand and gravel) in the Columbia River reservoirs below McNary tend
4073 to persist in these areas. The Bonneville Reservoir retains a large volume of relict fine sand that
4074 was likely deposited behind the massive Bridge of the Gods landslide 550 years ago. Episodic
4075 high sediment loading from Cascade Range tributaries will continue to provide coarse material
4076 that deposits as bed material at tributary confluences with the Columbia. The reservoirs below
4077 McNary hydraulically trap some suspended sediment passing McNary Dam and from tributary
4078 inflow directly to the reservoirs, resulting in shallow silt deposits on coarser bed material.
4079 Below Bonneville Dam, deep historical bed material deposits along with Cascade Range
4080 tributary inflow supply a bed composed primarily of medium to fine sand. Large sand waves can
4081 form in all sections of the tidal reach below Bonneville Dam, indicating active reworking and
4082 transport of bed material within the reach.

4083 ***Region D – Lower Columbia River Navigation Channel Dredging Volumes***

4084 The current 43-foot-deep Lower Columbia River Federal Navigation Channel (LCR FNC) was
4085 authorized by Section 101(b)(13) of the Water Resources Development Act of 1999 (Public Law
4086 106-53), and Division H, Section 123 of the Consolidated Appropriations Act of 2004 (Public Law
4087 108-199), and constructed from 2005 to 2010. The previously authorized LCR FNC was
4088 authorized to a shallower 40-foot-deep channel. The current channel is:

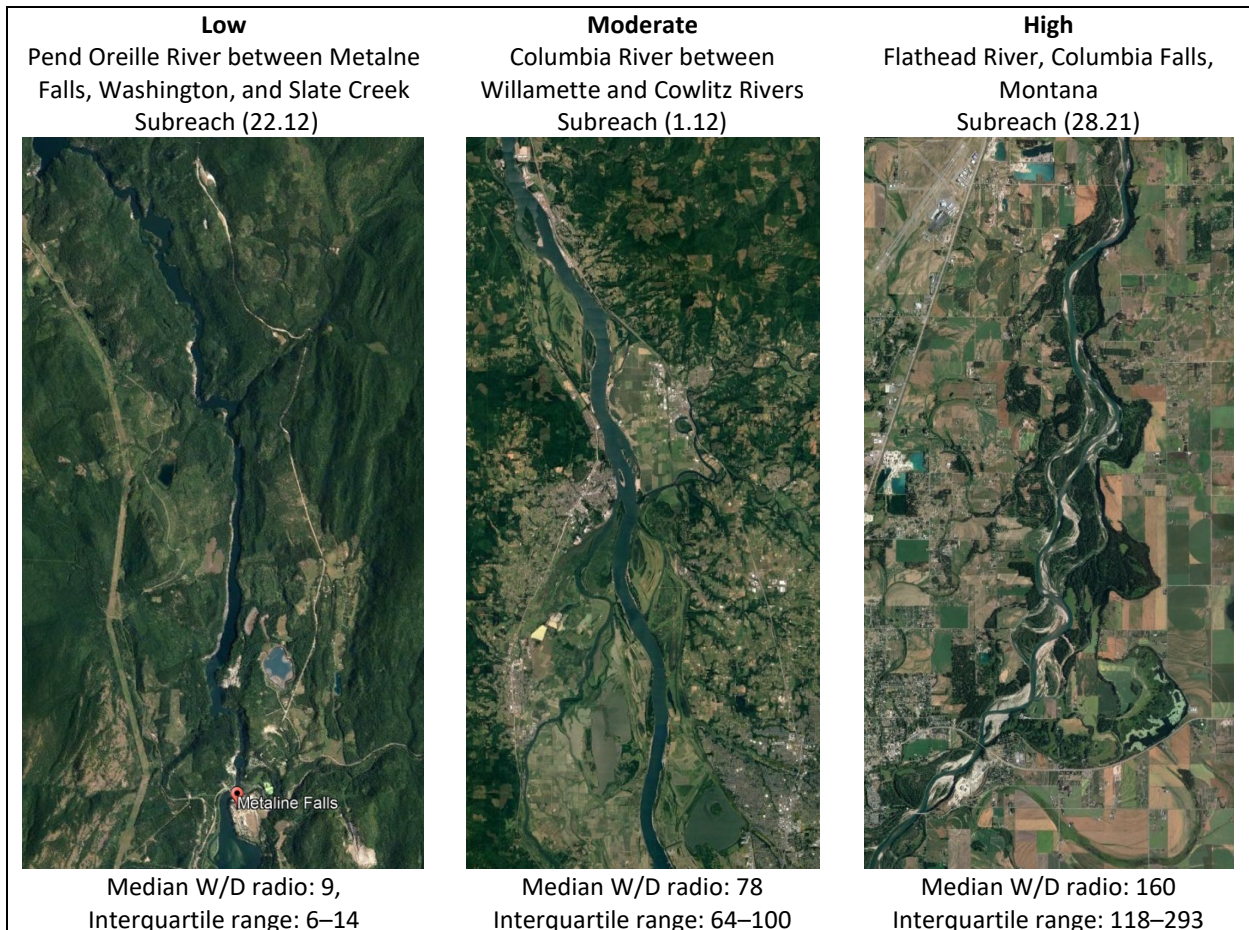
- 4089 • 43 feet deep and 600 feet wide from RM 3.0 to 101.4
- 4090 • 43 feet deep and 500 feet wide from RM 101.4 to 105.5
- 4091 • 43 feet deep and 400 feet wide in the downstream 1.5 miles of Oregon Slough
- 4092 • 35 feet deep from RM 105.5 to 106.5

4093 The rapidly changing and uncontrollable shoaling (shallow) conditions within the LCR FNC
4094 require continual maintenance dredging. Segments of the LCR FNC are dredged on an annual or
4095 semi-annual basis due to reoccurring shoals. Shoals require dredging depending on intensity
4096 and timing of flows and seasons. The Corps also relies on channel training features, including
4097 pile dikes, to scour sediments from the LCR FNC and thereby reduce the need for maintenance
4098 dredging over time. Present sedimentation processes require that the Corps annually remove 6
4099 to 10 million cubic yards (MCY) of sand from the LCR FNC below Bonneville Dam. Dredged
4100 material is primarily placed in-water or adjacent to the LCR FNC, along the shoreline, and at
4101 upland sites, but the material can also be placed at designated ocean disposal and near-shore
4102 sites.

4103 **RIVER MORPHOLOGY**

4104 The width to depth (W/D) ratio is a measure of bankfull (i.e., active channel) width to mean
4105 bankfull depth perpendicular to stream flow (Figure 3-105). High W/D ratios tend to reflect
4106 river reaches that have wide, connected floodplains or are geomorphologically complex, such
4107 as river confluences. In the Columbia River Basin, high W/D ratio reaches are typically free-
4108 flowing alluvial reaches like the Hanford Reach of the Columbia River or unique geomorphic
4109 features. An example of a unique feature is the Snake and Walla Walla River confluences with
4110 the Columbia River immediately upstream of the Wallula Gap where the Columbia River was
4111 carved wide by the Missoula Floods and is impounded by McNary Dam.

4112 Low W/D ratios tend to indicate geologically or anthropogenically confined reaches with little
4113 floodplain connection and deeper channels that have high sediment transport potential. Within
4114 the area of analysis, low W/D ratio is typically due to natural valley confinement such as on the
4115 South Fork Flathead River immediately downstream of Hungry Horse Dam where the river flows
4116 in a deep mountain canyon. The majority of reaches in the study area exhibit a W/D ratio
4117 between 10 and 100 for annual peak flows.



4118 **Figure 3-105. River Planform Examples of Relatively Different Width to Depth Ratio Ranges**
4119 **Observed in the Columbia River System study area.**

4120 **Region A – Kootenai River Morphology**

4121 In the 26 river miles between Libby Dam and Kootenai Falls, median W/D ratios are moderate
4122 (68 to 78) with an interquartile range between 45 and 118. Downstream of Kootenai Falls, the
4123 river enters the 33-mile-long Canyon Reach with a median W/D ratio of 50 and an interquartile
4124 range between 29 and 74.

4125 Relatively moderate to high W/D ratios occur in the active alluvial Braided Reach of the
4126 Kootenai River with an interquartile range between 70 and 200 and median around 90. This is a
4127 transitional reach from the steeper, confined upstream Canyon Reach (median W/D ratio
4128 around 50) to the flat-gradient expansive Meander Reach that enters Kootenay Lake. Despite
4129 the wide valley and high relative W/D ratio, the Braided Reach has experienced levee
4130 construction that confined the active valley by approximately 50 percent.

4131 Low W/D ratios are observed downstream in the Meander Reach of the Kootenai River. Despite
4132 the expansive valley width due to its geologic history as a former embayment of the Glacial
4133 Kootenai Lake, the reach exhibits low W/D ratio with an interquartile range between 18 and 33
4134 and a median around 23. Continuous levees on both banks have reduced the floodplain by 90
4135 percent and confined the active valley by 66 percent. The moderately active channel has
4136 greater depths than the upstream Braided Reach, adding to the low W/D ratio.

4137 **Region A – Flathead, Clark Fork, and Pend Oreille Rivers Morphology**

4138 Within the Flathead, Clark Fork, and Pend Oreille Rivers below SKQ Dam, there is great
4139 variability in W/D ratios.

4140 Between Hungry Horse and SKQ Dams, the upstream and downstream ends of the major reach
4141 have low W/D ratios while the middle reaches and Flathead Lake have high W/D ratios.
4142 Immediately downstream of Hungry Horse Dam the South Fork Flathead River has a single-
4143 thread stream channel in a narrow bedrock canyon resulting in low W/D ratio with a median
4144 less than 30. The Polson to SQK Dam reach is similarly a single-thread channel flowing in a
4145 narrow gorge cut through bedrock.

4146 From the confluence of the South Fork Flathead River with the mainstem Flathead River
4147 downstream to Polson, the reaches exhibit high W/D ratios (median between 135 and 160). The
4148 reaches upstream of Flathead Lake are characterized by an anastomosing stream channel
4149 within a wide valley filled with thick unconsolidated deposits. Flathead Lake itself is simply
4150 immensely wide and not necessarily well represented by the W/D ratio metric as it is
4151 fundamentally a naturally formed lake.

4152 The highest W/D ratios in Region A are seen at the Clark Fork River Delta (median around 85),
4153 which is the largest area of contiguous wetland complex in the Pend Oreille River System. The
4154 delta extends roughly 4 miles downriver from the town of Clark Fork, Idaho, and is roughly 3
4155 miles wide where the delta meets Lake Pend Oreille. The Indian Creek to River Bend subreach
4156 below Albeni Falls Dam is another high W/D ratio reach with an interquartile range between

4157 106 and 160 and a median near 132. The valley between the Selkirk Mountains to the east and
4158 the Kalispell Mountains to the west becomes wide at this point.

4159 Reaches of low W/D ratios are seen throughout the Clark Fork River between Thompson Falls
4160 Dam and Cabinet Gorge Dam with median ratios between 17 and 38. This reach follows the
4161 Hope fault, which lies on the riverbed as a structural separation of the Cabinet and Bitterroot
4162 Mountains (USGS 1946). Near Cabinet Gorge, there are now vertical rock cliffs hundreds of feet
4163 high. Low W/D ratios are also present downstream of Box Canyon Dam between Metaline Falls
4164 and Boundary Dam with median ratios less than 10.

4165 **Region B – Middle Columbia River Morphology**

4166 Between Grand Coulee Dam and the U.S.-Canada border, there are four defined subreaches of
4167 the middle Columbia River spanning approximately 143 river miles. The three upstream-most
4168 subreaches constitute approximately 99 river miles upstream of the Spokane River confluence
4169 with median W/D ratios between 37 and 45 and an interquartile range between 26 and 77. The
4170 lower 44 river miles downstream of the Spokane River confluence comprise the lower Lake
4171 Roosevelt subreach with a median W/D ratio of 25 and an interquartile range between 19 and
4172 34.

4173 Downstream of Grand Coulee Dam to the Yakima River confluence there are two reaches that
4174 exhibit high W/D ratios. Within the Upper Wells Reservoir subreach, there is high variability of
4175 W/D ratios (interquartile range between 30 and 300) including a wide and shallow area near
4176 the Okanogan River confluence at Brewster, Washington. The second highest W/D ratio
4177 subreach extends from Lower Wanapum Reservoir downstream to Richland, Washington, with
4178 median W/D ratios between 90 and 100. Despite appearing as a continuously wide W/D zone,
4179 the river upstream of Priest Rapids Dam is impounded while the Hanford and Richland Reaches
4180 are free-flowing. The inundated width at the Wanapum and Priest Rapids projects is particularly
4181 wide relative to the depth of the reservoirs, resulting in the high W/D ratio. The free-flowing
4182 alluvial reaches downstream have bar and island complexes throughout. There are two Middle
4183 Columbia reaches that exhibit low W/D ratios. Chief Joseph Reservoir is narrowly confined in
4184 Columbia Plateau bedrock, particularly in the downstream portion of the reservoir with a
4185 median W/D ratio around 12. Low W/D ratios are also observed downstream in the Lower Rock
4186 Island Reservoir reach near the community of Wenatchee, Washington, with a median W/D
4187 ratio around 40 and the 25th percentile ratio near 20.

4188 The Middle Columbia River from Grand Coulee Dam to the Yakima River confluence is
4189 extensively shaped by Ice Age outburst flooding. Below Grand Coulee, the Columbia River has
4190 an irregular channel with meanders that are narrowly confined by Columbia Plateau bedrock
4191 bluffs to Bridgeport, Washington. Downstream of Bridgeport, the Columbia River flows along
4192 the border between the Columbia Plateau and North Cascade province. The reach between
4193 Bridgeport and Priest Rapids Dam is a semi-confined channel separated by alluvial valleys.
4194 Below Priest Rapids Dam, the free-flowing alluvial Hanford Reach flows along the edge of
4195 Channeled Scabland.

4196 **Region C – Clearwater and Lower Snake River Morphology**

4197 The Clearwater and Lower Snake River reaches are cut deeply into the Columbia River Basalt
4198 Plain. In the lower subreach between Ice Harbor and McNary Reservoir confluence, the Snake
4199 River enters the downstream portions of the Channeled Scablands carved by Ice Age floods
4200 with a median W/D ratio around 130. The Ice Harbor Reservoir subreach is distinct in that there
4201 are localized areas of both relatively high and low W/D ratio zones intermittently occurring
4202 within the subreach with a median W/D ratio of around 50. This variability demonstrates the
4203 scale and complexity of the alternating slots, pools, and bars carved into the basalt plain by Ice
4204 Age events. Between Ice Harbor Dam and the Clearwater confluence near Lewiston, Idaho, the
4205 Snake River is more confined with median subreach W/D ratios between 30 and 70. While
4206 portions of the free-flowing Clearwater and Snake Rivers upstream of Lower Granite Reservoir
4207 are highly confined in a steep and deep valley, median W/D ratios range between 40 and 110.

4208 **Region D – Lower Columbia River Morphology**

4209 Similar to the Lower Snake River below Ice Harbor, the McNary Reservoir reach is cut deeply
4210 into the Columbia River Basalt Plain and occupies the downstream portions of the Channeled
4211 Scablands carved by Ice Age floods. In the McNary Reservoir area, the subreach between the
4212 Snake River confluence and Wallula is characterized by a relatively high W/D ratio with a
4213 median of nearly 500. This wide and shallow reach upstream of the bedrock basalt Wallula Gap
4214 was carved by the Missoula Floods and is impounded by McNary Dam. The alluvial Snake and
4215 Walla Walla River confluences with the Columbia River are both located in this subreach.

4216 The Columbia River below McNary cuts a narrow sea-ward path through the Cascade Range
4217 before meeting the north end of the Willamette Valley. The Columbia River then passes
4218 through the Coast Range before flowing into the Pacific Ocean. Columbia River waters are
4219 affected by the tide upstream to Bonneville Dam. Prior to construction of the dam, the head of
4220 tide extended 3 miles further upstream to Cascade Falls near the town of Cascade Locks,
4221 Oregon, and the site of the historical Bridge of the Gods Landslide.

4222 On the Columbia River below McNary Dam, there are three areas that exhibit high W/D ratios.
4223 The upstream most reach is the upper John Day Reservoir near the Blalock Islands where the
4224 valley is wide and the river flows through Quaternary deposits. Further downstream, below
4225 Bonneville Dam, in the area between Skamania and Vancouver, Washington, are free-flowing
4226 sand bed reaches at the downstream end of the Columbia River Gorge where the river meets
4227 the wide Willamette Valley. The most downstream zone is the Columbia River below the
4228 Cowlitz River, a zone that includes the wide and shallow tidal estuary.

4229 Two Lower Columbia subreaches exhibit moderately low W/D ratios. Upstream is The Dalles
4230 Dam to Memaloose Island subreach where the Columbia River passes through a tightly
4231 confined bedrock slot downstream of the now inundated Celilo Falls with a median W/D ratio
4232 around 50. Downstream is the Cascade Falls to Bonneville Dam subreach which is confined from
4233 the north by remnants of the Bridge of the Gods Landslide with a median W/D ratio under 20.

4234 **3.3.3 Environmental Consequences**

4235 Environmental consequences related to river mechanics processes were evaluated in a
4236 comparative nature between a select MO and the baseline No Action Alternative. The general
4237 approach for evaluating system response for river mechanics was to use the stochastic daily
4238 output from the quantitative hydroregulation planning models as analysis inputs to compute a
4239 suite of seven quantitative metrics as described in Section 3.3.3.1, below. Note that in order to
4240 accurately represent spatiotemporal effects, the hydroregulation model analyses were applied
4241 using daily average values over the entire FCRPS basin and metrics presented herein are limited
4242 to the previously identified CRS projects. Due to a number of limitations associated with the
4243 H&H modeling process (see Appendix B), the baseline conditions established by the No Action
4244 Alternative results may not necessarily completely characterize the actualized conditions. More
4245 specifically, the daily average resolution of H&H results are limited in that sub-daily variability is
4246 not represented. The most sensitive parameter to sub-daily variability is expected to be
4247 reservoir operational stage which is used to compute energy grade slope and subsequently
4248 boundary shear stress, one of the primary inputs for sediment transport metrics. Nonetheless,
4249 considering the size of the study area and the stochastic methodology used, the No Action
4250 Alternative and MO results were deemed sufficiently representative to adequately describe the
4251 hydrology and hydraulics as required to establish a general baseline of the study area for trend
4252 and departure analysis.

4253 Environmental consequence impacts are identified for each of seven river mechanics metrics
4254 based on thresholds of relative change (MO versus No Action Alternative) normalized to five
4255 levels (No Effect, Negligible, Minor, Moderate, and Major). To facilitate interpretation, the
4256 results for the estimated environmental consequences are presented in the following sections
4257 organized by each alternative and grouped by CRS project type (storage or run-of-river).

4258 **3.3.3.1 Analysis Metrics**

4259 Both quantitative and qualitative assessment methods were used to assess relative potential
4260 changes to river mechanics (sediment transport and geomorphology) for each MO. Seven
4261 quantitative metrics were developed to represent various physical characteristics and processes
4262 that could affect storage reservoirs, run-of-river reservoirs, and free-flowing reaches as
4263 enumerated below.

- 4264 • Storage Project Metrics
 - 4265 ○ Head of Reservoir Sediment Mobilization
 - 4266 ○ Sediment Trap Efficiency
 - 4267 ○ Shoreline Exposure
- 4268 • Run-of-River Reservoirs and Free-Flowing Reach Metrics
 - 4269 ○ Potential for Sediment Passing Reservoirs and Reaches
 - 4270 ○ Potential for Bed Material Change

- 4271 ○ Potential Change to Width to Depth Ratio
- 4272 ○ Potential Changes to Navigation Channel Dredging Volumes

4273 These seven scalar metrics are derived as deterministic calculations based on the H&H
4274 numerical modeling work (see Section 3.2.2.1) which established stochastic datasets that
4275 represent the system state of hydrology, hydroregulation, and riverine hydraulics. While
4276 dimensionally consistent, the geomorphic and sediment transport metrics are intended to
4277 provide a measure of relative change between a single MO and the baseline No Action
4278 Alternative insofar as it relates to trends in hydraulic departure for a select MO. It is also
4279 important to note that the stochastic hydrology for the No Action Alternative (see Section 3.2)
4280 was derived assuming climactic stationarity (i.e., without climate change). A discussion of
4281 sediment and geomorphology for the No Action Alternative under a future with climate change
4282 is presented separately in Chapter 4.

4283 Due to the large size of the study area, the spatiotemporal variability of supporting calibration
4284 data (e.g., bed material gradation and sediment supply), and limitations of the base input
4285 planning models, the scalar magnitude of a select metric at a discrete location and time may
4286 not necessarily represent actualized conditions. The quantitative metrics were interpreted
4287 within a subreach context to estimate qualitative trends for anticipated impacts at various
4288 locations within the study area. In addition, for the Environmental Consequences assessment of
4289 the *Breach Snake Embankments* measure under MO3, a numerical mobile bed riverine
4290 hydraulic model was developed as described in Section 3.4 of Appendix C. Additional detail
4291 regarding the geomorphology and sediment transport metrics can be found in Appendix C.

4292 **STORAGE PROJECT METRICS**

4293 There are six CRS dams that are designed and operated for flood, irrigation, or other storage
4294 purposes: Libby, Hungry Horse, Albeni Falls, Grand Coulee, John Day and Dworshak. Note that
4295 while John Day can be operated as a run-of-river project, it also includes a small amount of
4296 storage and thus was also evaluated for the storage project metrics. Operators change the pool
4297 elevation at these storage projects over large ranges throughout the year to capture and
4298 release water in specifically managed ways.

4299 **Head of Storage Reservoir Sediment Mobilization**

4300 The head-of-reservoir sediment mobilization metric is designed to indicate the potential for
4301 changes in sediment scour and deposition patterns in the most upstream portion of storage
4302 reservoirs. In dams that use large amounts of storage volume and operate over a wide range of
4303 elevations throughout the year, the transition from riverine to reservoir conditions can shift
4304 upstream and downstream considerable distances. If reservoir drawdown leaves the delta
4305 exposed during high-flow periods, the upper layers of delta will be eroded and transported
4306 farther into the reservoir, potentially increasing turbidity and downstream sediment deposit
4307 thickness. Changes in storage project elevations or changes to the flow of water and sediment
4308 into the reservoir can result in changes to the head-of-reservoir erosion and deposition

4309 patterns. This metric compares the paired relationships of flow and stage over time to indicate
4310 the potential for change in sediment mobilization at the head-of-reservoir for each alternative.
4311 Changes in delta sediment mobilization could alter the sediment load farther downstream
4312 within the reservoir and potentially the amount of sediment passing a dam, particularly during
4313 high-flow periods.

4314 **Storage Reservoir – Sediment Trap Efficiency**

4315 The sediment trap efficiency metric estimates the potential for changes in the amount of
4316 sediment that can deposit within or pass through the storage reservoirs. Trap efficiency is the
4317 proportion of inflowing sediment deposited in the reservoir relative to the total incoming
4318 sediment load. The trap efficiency is computed based on the ratio of reservoir storage volume
4319 to annual inflow. Because the volume of water stored at any given time in the storage projects
4320 can vary between MOs, there is potential for the amount of material being deposited in the
4321 reservoir to change between MOs. This metric compares the paired relationship of flow and
4322 reservoir storage to indicate the potential for changes in the amount of sediment being trapped
4323 by the storage projects for each alternative. The actual amount of sediment trapped is
4324 dependent not only on trap efficiency but also the incoming sediment load. Qualitative
4325 inferences are discussed on potential trap efficiency changes using sediment source
4326 documentation where available in the affected environment section (3.3.2).

4327 **Storage Reservoir – Shoreline Exposure**

4328 Shoreline erosion of bank sediments along reservoir margins is a complex process that is
4329 influenced by the cumulative effects of wave erosion, reservoir currents, precipitation runoff,
4330 freeze-thaw, soil properties, exposure, and vegetation density and type. One commonly
4331 observed process is that during times of extended reservoir drawdown, exposed un-vegetated
4332 shoreline soils that were previously saturated are prone to erosion and slumping. The shoreline
4333 exposure metric was developed as a surrogate for shoreline erosion processes. It compares the
4334 number of days that the reservoir water surface spends at any elevation to identify change in
4335 shoreline exposure and indicate the potential for change in shoreline erosion in the CRS storage
4336 projects. Elevation-duration curves used in this metric are developed from daily average data
4337 extracted from the 5,000-year stochastic hydroregulation operations model. The curves are
4338 integrated to calculate an average and are compared with the average of the No Action
4339 Alternative baseline. While the shoreline exposure metric does not directly consider reservoir
4340 draft rate, it does represent the duration effects that could result from draft rate operational
4341 measures.

4342 Absolute shoreline exposure differences less than ± 5 feet are likely not discernable within a
4343 storage reservoir due to sub-daily operational fluctuations and other processes such as waves,
4344 which occur within a similar range. A difference of at least ± 5 feet is estimated to be the
4345 threshold when shoreline effects would be observable on the landscape and would be
4346 considered minor. Differences greater than ± 10 feet would be observable and would be
4347 expected to result in moderate changes in shoreline exposure. A modification in the operational
4348 range of a storage project would be required to generate major changes in shoreline exposure

4349 with existing shoreline becoming permanently exposed or submerged. However, none of the
4350 analyzed MO operational measures changed the operational range at the CRS storage projects.

4351 An additional metric for shoreline erosion was developed to evaluate potential impacts to
4352 cultural resources. This metric considered draft frequency and amplitude and is detailed in
4353 Section 3.16.3.

4354 **RUN-OF-RIVER RESERVOIR AND FREE-FLOWING REACH METRICS**

4355 The remaining CRS reservoirs within the study area (Chief Joseph, Lower Granite, Little Goose,
4356 Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville) are run-of-river dams that
4357 do not store water for later discharge. Note that while John Day includes a small amount of
4358 storage, it can also be operated as a run-of-river project. Run-of-river reservoirs and free-
4359 flowing reaches include all the river reaches downstream of CRS storage projects. Run-of-river
4360 reservoirs are formed by dams that are operated to discharge water downstream at rates that
4361 generally match the upstream inflows. Bonneville Dam is an example of a run-of-river project
4362 that operates in a small range of pool elevations for daily or weekly hydropower purposes but
4363 does not attempt to store water for release in later seasons. Free-flowing reaches are portions
4364 of the river that are not influenced by the backwater of a downstream reservoir. The Flathead
4365 River downstream of Hungry Horse Dam and upstream of Flathead Lake is an example of a free-
4366 flowing reach.

4367 **Potential for Sediment Passing Reservoirs and Reaches**

4368 This metric estimates the size of material that can be held in suspension in the water column
4369 through each run-of-river reservoir and free-flowing reach due to operations of CRS projects.
4370 Water flowing in nature is predominately turbulent with chaotic changes in flow intensity and
4371 direction occurring at many scales internal to the overall downstream movement of the water.
4372 These turbulent forces can be strong enough to hold small sediment particles in suspension in
4373 the water column. The more energetic the turbulent forces, the larger the particle that can be
4374 suspended. Changes in the hydraulic conditions within the run-of-river reservoirs and reaches
4375 can change the ability of the river to transport sediment high in the water column. This metric
4376 calculates the grain size that can be held with 100 percent of its transporting mass in
4377 suspension for a given hydraulic condition using the Rouse profile (Rouse 1937). Comparison of
4378 the suspended sediment size between MOs as well as upstream and downstream in a single
4379 MO can inform managers whether there is potential for changes in material passing through or
4380 settling in a run-of-river reservoir or free-flowing reach.

4381 **Potential for Bed Material Change**

4382 This metric is designed to indicate the hydraulic potential for the bed of the river to become
4383 coarser (sand to gravel) or finer (gravel to sand) due to operations of CRS projects. Changes in
4384 operations can alter hydraulic conditions in run-of-river reservoirs and free-flowing reaches
4385 such that the river can move more or less riverbed sediment of various size classes. A change in
4386 the hydraulic ability for a reach to move sediment does not necessarily indicate that bed

4387 material will change. Sediment of specific size classes must be available in the reach at a
4388 sufficient supply for a change to occur. A bedrock or heavily armored (i.e., coarse) bed may
4389 withstand increases in the hydraulic capacity to transport sediment without changing.
4390 Conversely, a decrease in hydraulic ability to move sediment may not result in finer material
4391 depositing if no finer material is being locally supplied or transported into the reach. This metric
4392 calculates the distribution of critical grain size at the subreach level for each alternative
4393 supplemented with qualitative interpretation of existing bed material and sediment load to
4394 estimate if there is potential for bed material to trend coarser or finer in run-of-river reservoirs
4395 and reaches.

4396 **Potential Changes in Width-Depth Ratio**

4397 This metric evaluates if proposed changes in reservoir operations will alter the range and
4398 frequency of W/D ratios relative to affected environment conditions. Storage reservoirs and
4399 run-of-river reservoirs alter the physical landscape of rivers. Reservoirs change the width and
4400 depth of river channels and connectivity to floodplain surfaces and wetlands. Changes in the
4401 river framework alter ecological functions, including habitat, water quality, and riparian
4402 corridors, to name a few. The affected environment has larger wetted widths and hydraulic
4403 depths relative to pre-dam conditions due to reservoir conditions. Changes in the W/D ratio can
4404 indicate a potential for departure in channel hydraulics, or wetland and floodplain availability.
4405 MOs that do not change the minimum or maximum operating levels within a reservoir affected
4406 reach would not be expected to have a change in W/D ranges. However, operation changes
4407 could alter the frequency of W/D ratios, affecting the frequency of connectivity to floodplain
4408 surfaces or wetlands depending on local topography. A dam breaching would be expected to
4409 result in the largest change to W/D ratios.

4410 **Potential Changes to Navigation Channel Dredging Volumes**

4411 This metric evaluates if there is an expected change in the volume of sediment needing to be
4412 dredged from the federally authorized navigation system to provide safe and efficient deep-
4413 and shallow-draft navigation. As a part of its Congressional authorization, the Corps operates
4414 and maintains the navigation system from Lewiston, Idaho, to the Pacific Ocean along the
4415 Snake and Columbia Rivers. Changes in flow have the potential to change the volume of
4416 material depositing in the navigation channel. This metric estimates the average annual volume
4417 of sediment depositing in the deep- and shallow-draft sections based on relationships between
4418 flow in the river and sediment shoaling and historical dredging rates.

4419 **ALTERNATIVE COMPARISON THRESHOLDS**

4420 The River Mechanics Technical Appendix (Appendix C) discusses the quantitative basis for the
4421 impact metrics and the thresholds for impact assessment. While the impact thresholds are
4422 specific to each metric, the five standardized levels can generally be described as listed in Table
4423 3-51.

4424 **Table 3-51. Summary of impact assessment thresholds used for River Mechanics assessment.**

No Effect:	No change
Negligible:	Change so small as to be unmeasurable and unable to be observed in the field.
Minor:	Change passes the likely threshold for being measurable but is likely not observable in the field.
Moderate:	Change is measurable and also passes the likely threshold for being observable in the field.
Major:	Change would be readily apparent to an observer in the field.

4425 An example of a minor impact in the “Potential for Bed Material Change” metric would be
 4426 hydraulic conditions modified from No Action Alternative such that the median grain size in the
 4427 bed (by mass) could change by up to 10 percent of a grain size class. This means that a fine sand
 4428 bed reach would still have fine sand bed. A moderate impact would mean the bed material
 4429 could change by up to 50 percent of a grain size class. A major impact would mean the bed
 4430 material could change by one whole grain class or more. An example of a major impact would
 4431 be a reach where the bed material could change from a fine sand to a medium sand or coarser
 4432 (larger grain sizes) or from a fine sand to a very fine sand or finer (smaller grain sizes).

4433 **3.3.3.2 NO ACTION ALTERNATIVE**

4434 Environmental consequences under the No Action Alternative are defined as the
 4435 geomorphology and sediment transport conditions that would be expected within the CRS
 4436 study area, without any changes in system configuration, maintenance, or operation. In other
 4437 words, the No Action Alternative shows what would happen if proposed new action was not
 4438 taken (Bass, Henderson, and Bogdan 2001) and project operations, maintenance, and
 4439 configuration remained the same as they were in September 2016 (the EIS Notice of Intent
 4440 date). For this No Action Alternative assessment, future geomorphology and sediment
 4441 transport conditions are evaluated for the next 50 years. River mechanics metrics related to the
 4442 No Action Alternative are generally described below from a process-based perspective, and
 4443 then further summarized by region for any unique location-specific impacts (Table 3-52).

4444 Under the No Action Alternative, water storage patterns are expected to be generally within
 4445 the same range as historically experienced. There is a wide range in the water elevation in the
 4446 storage reservoirs depending on the season and precipitation, and this variation will continue
 4447 to control the location of the transition between riverine and reservoir conditions. The flow
 4448 rates and project operating stages within the system are expected to remain within the
 4449 historical range of variations. The incoming flow rate and downstream stage within a river
 4450 segment or reservoir directly affect the hydraulic grade, which is the primary driver of sediment
 4451 transport and suspension.

4452 Shoreline erosion occurs to varying degrees in the storage reservoirs, depending on water level,
 4453 wind (wave erosion), ice, currents, and other processes. Under the No Action Alternative, the
 4454 duration and timing of reservoir water levels are not expected to change compared to the

4455 historical range. Similarly, it is anticipated that winds, freeze-thaw patterns, and flow rates
4456 within the reservoir would be within the historically experienced range.

4457 Under the No Action Alternative, climatic conditions, land use patterns, and the amount of
4458 sediment entering the reservoirs from upstream is expected to remain the same as historically
4459 experienced. Climatic conditions, land use, and precipitation are major drivers for sediment
4460 erosion and yield into the river system. Climatic conditions were assumed to be consistent
4461 within historical ranges. The range of precipitation is expected to be within the historical range
4462 experienced, including some very wet and some very dry years. Land use is anticipated to
4463 follow similar patterns as currently experienced, with discrete population centers in some
4464 areas, but with a large portion of the watershed held as public lands. Sources of sediment such
4465 as agricultural fields are expected to continue cultivation in a manner similar to the current
4466 conditions. Under the No Action Alternative, the sediment loading throughout the basin is not
4467 expected to change from the historical range experienced.

4468 **Table 3-52. Summary of No Action Alternative River Mechanics Impact Estimates**

Metric	No Action Impact
Storage Projects	
Head of Reservoir Sediment Mobilization	Sediment will continue to deposit at the head of reservoirs (deltas) due to the slow-velocity backwater zone caused by the dams. Erosion and transport of head of reservoir sediment are expected to continue as a result of fluctuating reservoir pools. The transport of sediment from the head of the reservoir (delta) further downstream are expected to remain within the historically experienced range.
Trap Efficiency	Reservoirs will continue to trap incoming sediment due to the slow-velocity backwater pool created by the dams. The amount of sediment trapped in storage reservoirs is expected to be within historical levels, since the reservoir operations and sediment loading are not expected to change.
Shoreline Exposure	The amount of time that the storage project water surface elevations spend at any given elevation will not change from historical conditions. Reservoir shoreline erosion is expected to continue at locations and rates similar to those historically experienced at each project.
Run-of-River Reservoirs and Free-Flowing Reaches	
Potential for Sediment Passing Reservoirs and Reaches	A portion of the incoming sediment load will continue to pass run-of-river reservoirs and free-flowing reaches at magnitudes and rates similar to those historically experienced.
Potential for Bed Material Change	Bed material erosion and deposition patterns will continue to be altered by the CRS, since flow rates, operational stages, and sediment loading to the system are expected to be similar to historical ranges. Deposition and finer bed-material gradation is expected to continue in areas backwatered by dams.
Potential Change in Width to Depth Ratio	Due to continued operation of the CRS, the overall geomorphic character of the rivers will have the majority of reaches impacted by reservoirs, creating larger W/D ratios than pre-dam conditions. Under NAA, the W/D ratio is not expected to change, since the operating water levels and flow rates within the system are expected to be within the historical range experienced.

Metric	No Action Impact
Potential Changes to Navigation Channel Dredging Volumes	Sediment loading into the FNC will continue and the navigation system will continue to be maintained through existing dredging authorities and operational plans. Under NAA, sediment loading into and sediment transport capacity within the FNC is not expected to change from the historical range of conditions.

4469 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

4470 **Storage Projects**

4471 Under the No Action Alternative in Region A, sediment transport, deposition, and erosion
4472 processes will continue to be impacted by CRSO. Head of Reservoir Sediment Mobilization, Trap
4473 Efficiency, and Shoreline Exposure processes will continue at a similar magnitude and rates to
4474 those described in the Affected Environment (Section 3.3.2.3).

4475 **Run-of-River Reservoir and Free-Flowing Reaches**

4476 Under the No Action Alternative in Region A, the Run-of-River Reservoir and Free-Flowing
4477 Reaches will continue to be impacted by CRSO. The sediment loads passing through each
4478 reservoir, altered bed material gradation, and altered W/D ratios will continue at magnitudes
4479 and rates similar to those described in the Affected Environment (Section 3.3.2.4).

4480 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

4481 **Storage Projects**

4482 Under the No Action Alternative in Region B, negligible change is expected in Storage Project
4483 metrics for Head of Reservoir Sediment Mobilization, Trap Efficiency, and Shoreline Exposure
4484 indicating that these processes will continue at magnitudes and rates similar to those described
4485 in the Affected Environment (Section 3.3.2.3). The negligible change in these metrics results
4486 from negligible change in water storage patterns, seasonal reservoir elevations, sediment
4487 loading, and sediment properties.

4488 **Run-of-River Reservoir and Free-Flowing Reaches**

4489 Under the No Action Alternative in Region B, negligible change is expected in the Run-of-River
4490 Reservoir and Free-Flowing Reach metrics for potential changes in Sediment Passing Reservoirs
4491 and Reaches, Bed Material Change, and Width-to-Depth Ratio, indicating that these processes
4492 will continue at magnitudes and rates similar to those described in the Affected Environment
4493 (Section 3.3.2.4). The negligible change in these metrics results from negligible change in flow
4494 rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment
4495 properties.

4496 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
4497 **HARBOR DAMS**

4498 **Storage Projects**

4499 Under the No Action Alternative in Region C, negligible change is expected in Storage Project
4500 metrics for Head of Reservoir Sediment Mobilization, Trap Efficiency, and Shoreline Exposure
4501 indicating that these processes will continue at magnitudes and rates similar to those described
4502 in the Affected Environment (Section 3.3.2.3). The negligible change in these metrics results
4503 from negligible change in water storage patterns, seasonal reservoir elevations, sediment
4504 loading, and sediment properties.

4505 **Run-of-River Reservoir and Free-Flowing Reaches**

4506 Under the No Action Alternative in Region C, negligible change is expected in the Run-of-River
4507 Reservoir and Free-Flowing Reach metrics for Potential changes in Sediment Passing Reservoirs
4508 and Reaches, Bed Material Change, and Width-to-Depth Ratio, indicating that these processes
4509 will continue at magnitudes and rates similar to those described in the Affected Environment
4510 (Section 3.3.2.4). The negligible change in these metrics results from negligible change in flow
4511 rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment
4512 properties.

4513 Under the No Action Alternative in Region C, negligible change is expected in the accumulation
4514 of sediment and FNC maintenance requirements. The negligible change results from negligible
4515 change in various factors that affect sediment accumulation including climatic conditions,
4516 watershed yield and loading to the reservoir, the hydraulic capacity to transport sediment
4517 material through the reservoir, and changes in the bed materials as detailed above. Currently
4518 dredging within the system occurs on the lower Columbia River and on the lower Snake River,
4519 in discrete locations. Areas which historically have required dredging (lock chamber
4520 approaches, the confluence of the Snake and Clearwater Rivers, harbor and port berthing areas
4521 and entrances) would still experience shoaling (buildup of sediment into shallow areas).
4522 Dredging within the LCR FNC and private dock-face/berthing areas to maintain navigation
4523 would still occur. Sediment management activities in the Snake River (as described in the PSMP,
4524 Corps 2014c) would continue as currently planned.

4525 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

4526 **Storage Projects**

4527 Under the No Action Alternative in Region D, negligible change is expected in Storage Project
4528 metrics for Head of Reservoir Sediment Mobilization, Trap Efficiency, and Shoreline Exposure,
4529 indicating that these processes will continue at magnitudes and rates similar to those described
4530 in the Affected Environment (Section 3.3.2.3). The negligible change in these metrics results
4531 from negligible change in water storage patterns, seasonal reservoir elevations, sediment
4532 loading, and sediment properties.

4533 **Run-of-River Reservoir and Free-Flowing Reaches**

4534 Under the No Action Alternative in Region D, negligible change is expected in the Run-of-River
4535 Reservoir and Free-Flowing Reach metrics for Potential Changes in Sediment Passing Reservoirs
4536 and Reaches, Bed Material Change, and Width-to-Depth Ratio, indicating that these processes
4537 will continue at magnitudes and rates similar to those described in the Affected Environment
4538 (Section 3.3.2.4). The negligible change in these metrics results from negligible change in flow
4539 rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment
4540 properties.

4541 Under the No Action Alternative in Region D, negligible change is expected in the accumulation
4542 of sediment and FNC maintenance requirements. The negligible change results from negligible
4543 change in various factors that affect sediment accumulation including climatic conditions,
4544 watershed yield and loading to the reservoir, the hydraulic capacity to transport sediment
4545 material through the reservoir, and changes in the bed materials as detailed above.

4546 **3.3.3.3 MULTIPLE OBJECTIVE ALTERNATIVE 1**

4547 See Section 2.3.3 for a complete description of MO1. Impacts related to MO1 relative to the No
4548 Action Alternative are summarized by region and enumerated in Table 3-53.

4549 **Table 3-53. Summary of Multiple Objective Alternative 1 River Mechanics Impact Estimates**

Metric	MO1 Impact
Storage Projects	
Head of Reservoir Sediment Mobilization	Negligible change in erosion or deposition processes and patterns at the head of storage project reservoirs with the exception of: Columbia River entering Lake Roosevelt. There is potential for a minor change in depositional patterns with temporary head-of-reservoir deposits shifting downstream, although available deposit volume is limited. Head-of-reservoir deposits may include contaminants (slag) that are also mobilized slightly farther downstream in the reservoir but are not expected to be transported past the dam. The ultimate long-term fate of head-of-reservoir sediments within the reservoir is expected to remain unchanged given there are no proposed changes in the Grand Coulee operational range. Draft duration related to the <i>Winter System FRM Space</i> measure at Grand Coulee Dam contributes to the impact.
Trap Efficiency	Negligible change in potential for storage projects to trap sediment indicating that reservoir sediment pass-through at CRS storage projects will continue at magnitudes and rates similar to the NAA.
Shoreline Exposure	Negligible change in the amount of time that the storage projects' water surface elevations spend at any given elevation, indicating that reservoir shoreline erosion processes are expected to continue at locations and rates similar to those under the NAA.
Run-of-River Reservoirs and Free-Flowing Reaches	
Potential for Sediment Passing Reservoirs and Reaches	Negligible change in the potential for sediment to pass run-of-river reservoirs and free-flowing reaches with the exception of:

Metric	MO1 Impact
	Lower Clearwater River above the Snake Confluence (Subreach 10.11). There is potential for a minor decrease in the amount of sediment passing the Clearwater River at the Snake and Clearwater River confluence. The <i>Modified Dworshak Summer Draft</i> measure causes the impact.
Potential for Bed Material Change	Negligible change in the processes that supply, transport, and deposit sediment in the system with the exception of: Lake Roosevelt Upper Reach on the Columbia River (Subreach 21.13). There is potential for a minor amount of coarsening of bed sediment at the head of Lake Roosevelt. Draft duration related to the <i>Winter System FRM Space</i> measure at Grand Coulee Dam contributes to the impact.
Potential Change in Width to Depth Ratio	Negligible change in the overall geomorphic character of the rivers.
Potential Changes to Navigation Channel Dredging Volumes	Snake River: Estimated average annual volume of sediment depositing in the Snake River navigation channel due to MO1 operations is less than 1% change from No Action. Lower Columbia River: Estimated average annual volume of sediment depositing in the LCR FNC due to MO1 operations is less than 1% decrease from the NAA.

4550 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

4551 **Storage Projects**

4552 Negligible change in Region A Storage Project metrics under MO1.

4553 **Run-of-River Reservoir and Free-Flowing Reaches**

4554 Negligible change in Region A Run-of-River Reservoirs and Free-Flowing Reach metrics under
4555 MO1.

4556 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

4557 **Storage Projects**

4558 Negligible change in Region B Storage Project metrics under MO1 with the exception of Head of
4559 Reservoir Sediment Mobilization at the **Columbia River entering Lake Roosevelt**. There is
4560 potential for a minor change in depositional patterns with temporary head-of-reservoir
4561 deposits shifting downstream, although available deposit volume is limited. Head-of-reservoir
4562 deposits may include contaminants (slag) that are also mobilized slightly farther downstream in
4563 the reservoir but are not expected to be transported past the dam. The ultimate long-term fate
4564 of head-of-reservoir sediments within the reservoir is expected to remain unchanged given
4565 there are no proposed changes in the Grand Coulee operational range. Draft duration related to
4566 the *Winter System FRM Space* measure at Grand Coulee Dam contributes to the impact.

4567 **Run-of-River Reservoir and Free-Flowing Reaches**

4568 Negligible change in Region B Run-of-River Reservoirs and Free-Flowing Reach metrics under
4569 MO1 with the exception of the Potential for Bed Material Change at the **Lake Roosevelt Upper**
4570 **Reach on the Columbia River** (Subreach 21.13). There is potential for a minor amount of
4571 coarsening of bed sediment at the head of Lake Roosevelt. Draft duration related to the *Winter*
4572 *System FRM Space* measure at Grand Coulee Dam contributes to the impact.

4573 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
4574 **HARBOR DAMS**

4575 **Storage Projects**

4576 Negligible change in Region C Storage Project metrics under MO1.

4577 **Run-of-River Reservoir and Free-Flowing Reaches**

4578 Negligible change in Region C Run-of-River Reservoirs and Free-Flowing Reach metrics under
4579 MO1 with the exception of the potential for sediment to pass run-of-river reservoirs and free-
4580 flowing reaches on the **Lower Clearwater River above the Snake Confluence (Subreach 10.11)**.
4581 There is potential for a minor decrease in the amount of sediment passing the Clearwater River
4582 at the Snake and Clearwater River confluence. The *Modified Dworshak Summer Draft* measure
4583 causes the impact. Negligible change in Region C to Navigation Channel Dredging volumes was
4584 estimated under MO1.

4585 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

4586 **Storage Projects**

4587 Negligible change in Region D Storage Project metrics under MO1.

4588 **Run-of-River Reservoir and Free-Flowing Reaches**

4589 Negligible change in Region D Run-of-River Reservoirs and Free-Flowing Reach metrics under
4590 MO1. Negligible change in Region D Navigation Channel Dredging volumes was estimated under
4591 MO1.

4592 **3.3.3.4 MULTIPLE OBJECTIVE ALTERNATIVE 2**

4593 Refer to the complete alternative description in Section 2.3.4. Impacts related to MO2 relative
4594 to the No Action Alternative are summarized by region and enumerated in Table 3-54.

4595 **Table 3-54. Summary of Multiple Objective Alternative 2 River Mechanics Impact Estimates**

Metric	MO2 Impact
Storage Projects	
Head of Reservoir Sediment Mobilization	Negligible change in erosion or deposition processes and patterns at the head of storage project reservoirs with the exception of: Dworshak Reservoir. There is potential for a minor change in depositional patterns with temporary head-of-reservoir deposits shifting downstream. Ultimate long-term fate of head-of-reservoir sediments within the reservoir is unchanged given no changes in Dworshak operational range. The <i>Slightly Deeper Draft for Hydropower</i> measure causes the impact.
Trap Efficiency	Negligible change in potential for storage projects to trap sediment indicating that reservoir sediment pass-through at CRS storage projects will continue at magnitudes and rates similar to the NAA.
Shoreline Exposure	Negligible change in the amount of time that the storage project water surface elevations spend at any given elevation with the exception of: Dworshak Reservoir. There is potential for a minor change in shoreline exposure at Dworshak with the reservoir being held at lower elevations for long enough to potentially cause a minor increase in the shoreline erosion pattern. The <i>Slightly Deeper Draft for Hydropower</i> measure causes the impact. At Lake Roosevelt, the increased shoreline exposure was estimated to be 1.8 feet, which is within the negligible interval. In addition, the proposed measure for slower drawdown from the <i>Planned Draft Rate at Grand Coulee</i> could have the potential to provide minor reductions in local landslides related to reservoir levels.
Run-of-River Reservoirs and Free-Flowing Reaches	
Potential for Sediment Passing Reservoirs and Reaches	Negligible change in the potential for sediment to pass run-of-river reservoirs and free-flowing reaches.
Potential for Bed Material Change	Current processes that supply, transport and deposit sediment in the system will continue at historical rates (same as NAA) with the exception of: Lower Flathead River between Stillwater and Flathead Lake (Subreach 28.13). There is potential for a minor, unobservable amount of fining of bed sediment in the reach immediately upstream of Flathead Lake. The impact results from slight reductions in Hungry Horse outflow, which dampens the energy grade as the Flathead River enters Flathead Lake backwater; the flow reduction is tied to the reduced outflows during the FRM period, which results from the <i>Slightly Deeper Draft for Hydropower</i> measure during winter months. Lake Roosevelt Upper Reach on the Columbia River (Subreach 21.13). There is potential for a minor amount of coarsening of bed sediment at the head of Lake Roosevelt. Draft duration from the <i>Winter System FRM Space</i> and <i>Slightly Deeper Drafts for Hydropower</i> measures at Grand Coulee contribute to the impact.
Potential Change in Width to Depth Ratio	Negligible change in the overall geomorphic character of the rivers.

Metric	MO2 Impact
Potential Changes to Navigation Channel Dredging Volumes	<p>Snake River: Estimated average annual volume of sediment depositing in the Snake River navigation channel due to MO2 operations is less than 1% change from the NAA.</p> <p>Lower Columbia River: Estimated average annual volume of sediment depositing in the LCR FNC due to MO2 operations is less than 1% increase from the NAA.</p>

4596 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

4597 **Storage Projects**

4598 Negligible change in Region A Storage Project metrics under MO2.

4599 **Run-of-River Reservoir and Free-Flowing Reaches**

4600 Negligible change in Region A Run-of-River Reservoirs and Free-Flowing Reach metrics under
 4601 MO2 with the exception of Potential for Bed Material Change within the **Lower Flathead River**
 4602 **between Stillwater and Flathead Lake (Subreach 28.13)**. There is potential for a minor amount
 4603 of fining of bed sediment in the reach immediately upstream of Flathead Lake. The impact
 4604 results from slight reductions in Hungry Horse outflow, which dampen the energy grade as the
 4605 Flathead River enters Flathead Lake backwater; the flow reduction is tied to the reduced
 4606 outflows during the FRM period, which result from the *Slightly Deeper Draft for Hydropower*
 4607 measure during winter months.

4608 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

4609 **Storage Projects**

4610 Negligible change in Region B Storage Project metrics under MO2.

4611 **Run-of-River Reservoir and Free-Flowing Reaches**

4612 Negligible change in Region B Run-of-River Reservoirs and Free-Flowing Reach metrics under
 4613 MO2 with the exception of the Potential for Bed Material Change within the **Lake Roosevelt**
 4614 **Upper Reach on the Columbia River (Subreach 21.13)**. There is potential for a minor amount of
 4615 coarsening of bed sediment at the head of Lake Roosevelt. Draft duration from the *Winter*
 4616 *System FRM Space and Slightly Deeper Drafts for Hydropower* measures at Grand Coulee
 4617 contributes to the impact.

4618 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
4619 **HARBOR DAMS**

4620 **Storage Projects**

4621 Negligible change in Region C Storage Project metrics under MO2 with the exception of Head of
4622 Reservoir Sediment Mobilization and Shoreline Exposure at Dworshak Reservoir. There is
4623 potential for a minor change in depositional patterns with temporary head-of-reservoir
4624 deposits shifting downstream at Dworshak Reservoir. The ultimate long-term fate of head-of-
4625 reservoir sediments within the reservoir is unchanged given no changes in Dworshak
4626 operational range. The *Slightly Deeper Draft for Hydropower* measure causes the impact. There
4627 is also potential for a minor change in shoreline exposure at Dworshak with the reservoir being
4628 held at lower elevations for long enough to potentially cause a minor increase in the shoreline
4629 erosion pattern. The *Slightly Deeper Draft for Hydropower* measure causes the impact.

4630 **Run-of-River Reservoir and Free-Flowing Reaches**

4631 Negligible change in Region C Run-of-River Reservoirs and Free-Flowing Reach metrics under
4632 MO2. Negligible change in Region C Navigation Channel Dredging volumes under MO2.

4633 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

4634 **Storage Projects**

4635 Negligible change in Region D Storage Project metrics under MO2.

4636 **Run-of-River Reservoir and Free-Flowing Reaches**

4637 Negligible change in Region D Run-of-River Reservoirs and Free-Flowing Reach metrics under
4638 MO2. Negligible change in Region D Navigation Channel Dredging volumes under MO2.

4639 **3.3.3.5 MULTIPLE OBJECTIVE ALTERNATIVE 3**

4640 See Chapter 2 for a complete description of the dam embankment breach alternative.

4641 Structural measures for this alternative include:

- 4642 • Breach Snake Embankments: Remove earthen embankments, as required, at each dam to
4643 facilitate reservoir drawdown at the lower Snake River dams.
- 4644 • Lower Snake Infrastructure Drawdown: Modify existing equipment and dam infrastructure
4645 at the lower Snake River dams to adjust to drawdown conditions (Existing equipment would
4646 not be used for hydropower generation but would be used as low-level outlets for
4647 drawdown below spillway elevations).
- 4648 • Additional Powerhouse Surface Passage: Construct additional powerhouse and surface
4649 passage routes at the McNary Project.

4650 Under MO3, four reservoirs will be drawn down and converted to a riverine environment. The
 4651 current reservoirs contain fine sediment deposits that will partially erode, leaving margin
 4652 sediment on high terraces behind. The new river bottom after breaching will initially become
 4653 finer and gradually coarsen over the long term. The change in the overall geomorphic character
 4654 will occur on the Snake and Clearwater Rivers within the backwater extents of Lower Granite
 4655 Reservoir downstream to the confluence with the Columbia River. River Mechanic metric
 4656 impacts related to MO3 relative to the No Action Alternative are summarized by region and
 4657 enumerated in Table 3-55. See Appendix C, *River Mechanics Technical Appendix*, for additional
 4658 information on estimated dam breaching impacts.

4659 **Table 3-55. Summary of Multiple Objective Alternative 3 River Mechanics Impact Estimates**

Metric	MO3 Impact
Storage Projects	
Head of Reservoir Sediment Mobilization	Negligible change in erosion or deposition processes and patterns at the head of storage project reservoirs.
Trap Efficiency	Negligible change in potential for storage projects to trap sediment, indicating that reservoir sediment pass-through at CRS storage projects will continue at magnitudes and rates similar to the NAA.
Shoreline Exposure	Negligible change in the amount of time that the storage project water surface elevations spend at any given elevation, indicating that reservoir shoreline erosion processes are expected to continue at locations and rates similar to the NAA.
Run-of-River Reservoirs and Free-Flowing Reaches	
Potential for Sediment Passing Reservoirs and Reaches	<p>Negligible change in the potential for sediment to pass run-of-river reservoirs and free-flowing reaches with the exception of:</p> <p>The Snake River from the upstream extents to Lower Granite Reservoir downstream to the Columbia River (<i>Reaches 6–9 and 11.1</i>) and the Clearwater River backwatered by Lower Granite Reservoir (<i>Subreach 10.1</i>). There is potential for a major increase in the size and amount of sediment passing these reaches. The <i>Breach Snake Embankments</i> measure causes the impact by converting four run-of-river reservoirs to a riverine environment.</p> <p>Columbia River from the Snake River confluence downstream to the Pacific Ocean (<i>Reaches 1–5</i>). Due to the increase in amount of sediment passing from the Snake River into the Columbia River, there is potential for a major increase in the amount of sediment passing downstream of the Snake River confluence. The <i>Breach Snake Embankments</i> measure causes the impact.</p>

Metric	MO3 Impact
Potential for Bed Material Change	<p>Current processes that supply, transport and deposit sediment in the system will continue at historical rates (same as NAA) with the exception of:</p> <p>The lower Snake River from the upstream extents of the CRS study area to Lower Granite Reservoir downstream to the Columbia River (Reaches 6–9 and Subreach 11.1) and the Clearwater River backwatered by Lower Granite Reservoir (Subreach 10.1). There is potential for a major amount of coarsening of bed sediment throughout these reaches. The <i>Breach Snake Embankments</i> measure causes the impact.</p> <p>The Columbia River from the Snake River confluence to McNary Dam (Subreach 5.1). Due to the increase in amount of sediment passing from the Snake River into the Columbia River, there is potential for a major increase in the amount of material depositing in McNary Reservoir. The bed material size may become finer in the short term and coarsen in the long term. The <i>Breach Snake Embankments</i> causes the impact.</p>
Potential Change in Width to Depth Ratio	<p>Negligible change in the overall geomorphic character of the rivers with the exception of:</p> <p>The lower Snake River from the upstream extents of the CRS study area to Lower Granite Reservoir downstream to the Columbia River (Reaches 6–9 and Subreach 11.1) and the Clearwater River backwatered by Lower Granite Reservoir (Subreach 10.1). There is a major change in geomorphic character in these reaches with the river becoming much shallower relative to its wetted width. The <i>Breach Snake Embankments</i> measure causes the impact. The four lower Snake River reservoirs contain fine sediment deposits that, following dam embankment removal, will partially erode leaving margin sediment on high terraces behind. The new lower Snake river bottom after breaching will initially become finer and gradually coarsen over the long term. The change in the overall geomorphic character will occur on the Snake and Clearwater Rivers within the backwater extents of Lower Granite Reservoir downstream to the confluence with the Columbia River.</p>
Potential Changes to Navigation Channel Dredging Volumes	<p>Snake River: Navigation maintenance of the Snake River FNC is assumed to cease following breaching of the four Snake River projects. Estimated change in the average annual volume of watershed sediment yield to the lower Snake River is less than 1% compared to the NAA. Following breaching of the dam embankments, this watershed sediment would pass the breached dam embankments and be routed to the Columbia River confluence as discussed below.</p> <p>Lower Columbia River: Estimated average annual volume of sediment depositing in the LCR FNC due to MO3 operations is less than 1% decrease from the NAA based on sediment load from the Lower Columbia River. In addition, near-term sedimentation effects following dam embankment breaching are expected to last up to 10 years as legacy sediment deposits within the reservoirs are incrementally eroded and re-deposited throughout the lower Snake River reach. Near-term sedimentation effects are expected to be particularly large in the upstream end of Lake Wallula above McNary Dam. The impacts of sediment deposition at left bank recreation and boat-launch sites below the Snake River confluence would likely be permanent. Long-term sedimentation effects would include continued deposition in quiescent areas prone to shoaling as a result of annual sediment delivery that had previously been trapped by the lower Snake River dams.</p>

4660 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

4661 **Storage Projects**

4662 Negligible change in Region A Storage Project metrics under MO3.

4663 **Run-of-River Reservoir and Free-Flowing Reaches**

4664 Negligible change in Region A Run-of-River Reservoirs and Free-Flowing Reach metrics under
4665 MO3.

4666 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

4667 **Storage Projects**

4668 Negligible change in Region B Storage Project metrics under MO3.

4669 **Run-of-River Reservoir and Free-Flowing Reaches**

4670 Negligible change in Region B Run-of-River Reservoirs and Free-Flowing Reach metrics under
4671 MO3. At Lake Roosevelt, the increased shoreline exposure was estimated to be 1.8 feet, which
4672 is within the negligible interval. In addition, the proposed measure for slower drawdown from
4673 the *Planned Draft Rate at Grand Coulee* could have the potential to provide minor reductions in
4674 local landslides related to reservoir levels.

4675 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE
4676 HARBOR DAMS**

4677 **Storage Projects**

4678 Negligible change in Region C Storage Project metrics under MO3.

4679 **Run-of-River Reservoir and Free-Flowing Reaches**

4680 Within Region C, significant changes were identified under MO3 for the Run-of-River Reservoirs
4681 and Free-Flowing Reach metrics caused by the *Breach Snake Embankments* measure, which
4682 converts four run-of-river reservoirs to a riverine environment. The spatial impact of change
4683 includes **the Snake River from the upstream extents to Lower Granite Reservoir downstream
4684 to the Columbia River confluence (Reaches 6–9 and Subreach 11.1)** and the **Clearwater River
4685 backwatered by Lower Granite Reservoir (Subreach 10.1)**. Within these reaches, there is
4686 potential for a major increase in the size and amount of sediment passing and a major amount
4687 of coarsening of bed sediment. There is also a major change in geomorphic character in these
4688 reaches, with the river becoming much shallower relative to its wetted width. The four lower
4689 Snake River reservoirs contain fine sediment deposits that following dam embankment removal
4690 will partially erode, leaving margin sediment on high terraces behind. The new lower Snake

4691 River bottom after breaching will initially become finer and gradually coarsen over the long
4692 term.

4693 Under MO3, navigation maintenance of the Snake River FNC is assumed to cease following
4694 breaching of the four Snake River projects. Following breaching of the dam embankments,
4695 watershed sediment will now pass the breached dam embankments and be routed to the
4696 Columbia River confluence.

4697 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

4698 **Storage Projects**

4699 Negligible change in Region D Storage Project metrics under MO3.

4700 **Run-of-River Reservoir and Free-Flowing Reaches**

4701 Within Region D, changes were identified under MO3 for the Run-of-River Reservoirs and Free-
4702 Flowing Reach metrics caused by the *Breach Snake Embankments* measure which converts four
4703 run-of-river reservoirs to a riverine environment. Due to the increase in the amount of
4704 sediment passing from the Snake River into the Columbia River, there is potential for a major
4705 increase in the amount of sediment passing downstream of the Snake River confluence. Due to
4706 the increase in amount of sediment passing from the Snake River into the Columbia River, there
4707 is potential for a major increase in the amount of material depositing in McNary Reservoir. The
4708 bed material size may become finer in the short term and coarsen in the long term.

4709 Under MO3, negligible changes were estimated in Region D Navigation Channel Dredging
4710 volumes based on sediment loads supplied from Region B. In addition, near-term
4711 sedimentation effects following dam embankment breaching are expected to last up to 10
4712 years as legacy sediment deposits within the reservoirs are incrementally eroded and re-
4713 deposited throughout the lower Snake River reach. Near-term sedimentation effects are
4714 expected to be particularly large in the upstream end of Lake Wallula above McNary Dam. The
4715 impacts of sediment deposition at left bank recreation and boat-launch sites below the Snake
4716 River confluence would likely be permanent. Long-term sedimentation effects would include
4717 continued deposition in quiescent areas prone to shoaling as a result of annual sediment
4718 delivery that had previously been trapped by the lower Snake River dams.

4719 **3.3.3.6 Multiple Objective Alternative 4**

4720 A complete description of MO4 can be found in Section 2.3.6. The MO includes structural
4721 measures as well as operational measures. The structural measures are related to powerhouse,
4722 turbine, spillway and fish passage features, and do not include the breaching of any dams. The
4723 operational measures include a long list of changes to current flow and power operations,
4724 including increasing the irrigation to authorized amounts which are detailed in Chapter 2.
4725 Impacts related to MO4 relative to the No Action Alternative are summarized by region and
4726 enumerated in Table 3-56.

4727 **Table 3-56. Summary of Multiple Objective Alternative 4 River Mechanics Impact Estimates**

Metric	MO4 Impact
Storage Projects	
Head of Reservoir Sediment Mobilization	<p>Negligible change in erosion or deposition processes and patterns at the head of storage project reservoirs with the exception of:</p> <p>Columbia River and Spokane River entering Lake Roosevelt. There is potential for a minor change in depositional patterns with temporary head-of-reservoir deposits shifting downstream, although available deposit volume is limited. Head-of-reservoir deposits may include contaminants (slag) that are also mobilized slightly farther downstream in the reservoir but are not expected to be transported past the dam. Ultimate long-term fate of head-of-reservoir sediments within the reservoir is expected to remain unchanged given there are no proposed changes in the Grand Coulee operational range. The <i>Winter System FRM Space</i>, <i>Planned Draft Rate</i>, and <i>McNary Flow Target</i> measures at Grand Coulee contribute to the impact.</p> <p>Columbia River Entering John Day Reservoir. There is potential for a minor change in head-of-reservoir sediment mobilization with deposits becoming coarser. The <i>Drawdown to MOP</i> measure at the John Day Project causes the impact.</p>
Trap Efficiency	Negligible change in potential for storage projects to trap sediment, indicating that reservoir sediment pass-through at CRS storage projects will continue at magnitudes and rates similar to the NAA.
Shoreline Exposure	<p>Negligible change in the amount of time that the storage project water surface elevations spend at any given elevation with the exception of Hungry Horse Reservoir. There is potential for a minor increase in shoreline exposure duration at Hungry Horse with the reservoir being held at lower elevations for a long enough period to potentially increase the erosion pattern. A combination of the <i>Hungry Horse Additional Water Supply</i> and <i>McNary Flow Target</i> measures causes the impact.</p> <p>At Lake Roosevelt, the increased shoreline exposure was estimated to be 4.7 feet, which is within the negligible interval. In addition, the proposed measure for slower drawdown from the <i>Planned Draft Rate at Grand Coulee</i> could have the potential to provide minor reductions in local landslides related to reservoir levels.</p>
Run-of-River Reservoirs and Free-Flowing Reaches	
Potential for Sediment Passing Reservoirs and Reaches	<p>Negligible change in the potential for sediment to pass run-of-river reservoirs and free-flowing reaches with the exception of</p> <p>Columbia River upstream of Kettle Falls, Washington, to the U.S.-Canada border (Subreaches 21.13 and 21.14). There is potential for a minor increase in the amount of sediment passing through the upper reach of Lake Roosevelt and into the middle reach of Lake Roosevelt Downstream of Kettle Falls, Washington. The <i>Winter System FRM Space</i>, <i>Planned Draft Rate</i>, and <i>McNary Flow Target</i> measures at Grand Coulee are contributors the impact.</p>

Metric	MO4 Impact
Potential for Bed Material Change	<p>Negligible change in the processes that supply, transport and deposit sediment in the system with the exception of:</p> <p>The Columbia River between Grand Coulee Dam and U.S.-Canada border (Reach 21). There is potential for a minor amount of bed sediment coarsening in Lake Roosevelt and reaches upstream to the U.S.-Canada border. <i>Winter System FRM Space, Planned Draft Rate and McNary Flow Target</i> measures at Grand Coulee contribute to the impact.</p> <p>Snake River downstream of Ice Harbor (Subreach 6.1). There is potential for a minor amount of bed sediment coarsening. The <i>Drawdown to MOP</i> measure at the McNary Project is causing in the impact.</p> <p>Columbia River from the Snake River Confluence to Wallula, Washington (Subreach 5.12). There is potential for a minor amount of bed sediment coarsening. The <i>Drawdown to MOP</i> measure at the McNary Project is causing in the impact.</p> <p>Columbia River at the upstream end of John Day Reservoir (Subreach 4.12). There is potential for a minor amount of bed sediment coarsening. The <i>Drawdown to MOP</i> measure at the John Day Project causes the impact.</p> <p>Columbia River between John Day Dam and Skamania, Washington (Reaches 2, 3, and subreach 1.23). There is potential for a minor amount of bed sediment coarsening. The <i>Drawdown to MOP</i> measure at The Dalles and Bonneville Projects causes this impact.</p>
Potential Change in Width to Depth Ratio	Negligible change in the overall geomorphic character of the rivers.
Potential Changes to Navigation Channel Dredging Volumes	<p>Snake River: Estimated average annual volume of sediment depositing in the Snake River navigation channel due to MO4 operations is less than 1% change from No Action.</p> <p>Lower Columbia River: Estimated average annual volume of sediment depositing in the LCR FNC due to MO4 operations is a less than 1% decrease from No Action.</p>

4728 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

4729 **Storage Projects**

4730 Negligible change in Region A Storage Project metrics under MO4 with the exception of
 4731 Shoreline Exposure at Hungry Horse Reservoir. There is potential for a minor increase in
 4732 shoreline exposure duration at Hungry Horse with the reservoir being held at lower elevations
 4733 for a long enough period to potentially increase the erosion pattern. A combination of the
 4734 *Hungry Horse Additional Water Supply* and *McNary Flow Target* measures causes the impact.

4735 **Run-of-River Reservoir and Free-Flowing Reaches**

4736 Negligible change in Region A Run-of-River Reservoirs and Free-Flowing Reach metrics under
 4737 MO4.

4738 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

4739 **Storage Projects**

4740 Negligible change in Region B Storage Project metrics under MO4 with the exception of Head of
4741 Reservoir Sediment Mobilization on the **Columbia River and Spokane River entering Lake**
4742 **Roosevelt**. There is potential for a minor change in depositional patterns with temporary head-
4743 of-reservoir deposits shifting downstream, although available deposit volume is limited. Head-
4744 of-reservoir deposits may include contaminants (slag) that are also mobilized slightly farther
4745 downstream in the reservoir but are not expected to be transported past the dam. The ultimate
4746 long-term fate of head-of-reservoir sediments within the reservoir is expected to remain
4747 unchanged given there are no proposed changes in the Grand Coulee operational range. The
4748 *Winter System FRM Space, Planned Draft Rate, and McNary Flow Target* measures at Grand
4749 Coulee contribute to the impact. At Lake Roosevelt, the increased shoreline exposure was
4750 estimated to be 4.7 feet, which is within the negligible interval. In addition, the proposed
4751 measure for slower drawdown from the *Planned Draft Rate at Grand Coulee* could have the
4752 potential to provide minor reductions in local landslides related to reservoir levels.

4753 **Run-of-River Reservoir and Free-Flowing Reaches**

4754 Negligible change in Region B Run-of-River Reservoirs and Free-Flowing Reach metrics under
4755 MO4 with the exception of the Potential for Sediment Passing Reservoirs and Reaches and
4756 Potential for Bed Material Change with *Winter System FRM Space, Planned Draft Rate, and*
4757 *McNary Flow Target* measures at Grand Coulee contributing to the impacts. On the **Columbia**
4758 **River between Grand Coulee Dam and U.S.-Canada border (Reach 21)**, there is potential for a
4759 minor amount of bed sediment coarsening in Lake Roosevelt and reaches upstream to the U.S.-
4760 Canada border. On the **Columbia River upstream of Kettle Falls, Washington, to the U.S.-**
4761 **Canada border (Subreaches 21.13 and 21.14)**, there is potential for a minor increase in the
4762 amount of sediment passing through the upper reach of Lake Roosevelt and into the middle
4763 reach of Lake Roosevelt downstream of Kettle Falls, Washington.

4764 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
4765 **HARBOR DAMS**

4766 **Storage Projects**

4767 Negligible change in Region C Storage Project metrics under MO4.

4768 **Run-of-River Reservoir and Free-Flowing Reaches**

4769 Negligible change in Region C Run-of-River Reservoirs and Free-Flowing Reach metrics under
4770 MO4 with the exception of the potential for a minor amount of bed sediment coarsening on the
4771 **Snake River downstream of Ice Harbor (Subreach 6.1)**. The *Drawdown to MOP* measure at the
4772 McNary Project is causing in the impact. Negligible change in Region C Navigation Channel
4773 Dredging volumes under MO4.

4774 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

4775 **Storage Projects**

4776 Negligible change in Region D Storage Project metrics under MO4 with the exception of Head of
4777 Reservoir Sediment Mobilization on the **Columbia River Entering John Day Reservoir**. There is
4778 potential for a minor change in head-of-reservoir sediment mobilization with deposits
4779 becoming coarser. The *Drawdown to MOP* measure at the John Day Project causes the impact.

4780 **Run-of-River Reservoir and Free-Flowing Reaches**

4781 Negligible change in Region D Run-of-River Reservoirs and Free-Flowing Reach metrics under
4782 MO4 with the exception of the Potential for Bed Material Change. On the **Columbia River from**
4783 **the Snake River Confluence to Wallula, Washington (Subreach 5.12)**. There is potential for a
4784 minor amount of bed sediment coarsening. The *Drawdown to MOP* measure at the McNary
4785 Project is causing in the impact. On the **Columbia River at the upstream end of John Day**
4786 **Reservoir (Subreach 4.12)**. There is potential for a minor amount of bed sediment coarsening.
4787 The *Drawdown to MOP* measure at the John Day Project causes the impact. On the **Columbia**
4788 **River between John Day Dam and Skamania, Washington (Reaches 2, 3, and subreach 1.23)**,
4789 there is potential for a minor amount of bed sediment coarsening. The *Drawdown to MOP*
4790 measure at The Dalles and Bonneville Projects causes this impact. Negligible change in Region D
4791 Navigation Channel Dredging volumes under MO4.

4792 **3.3.4 Tribal Interests**

4793 As described above, MO1, MO2, and MO4 generally result in negligible to minor changes in
4794 metrics used to analyzed effects to river mechanics processes. Tribal interests under those
4795 alternatives would not be impacted. MO3 includes a measure to breach the downstream-most
4796 four dam embankments on the Snake River which would result in major changes to river
4797 mechanics processes and corresponding metrics. The MO3 alternative would change the lower
4798 Snake River landscape that is currently backwatered by the four dams (Lower Granite, Little
4799 Goose, Lower Monumental, and Ice Harbor) and the localized areas of the Columbia River
4800 below the Snake River confluence.

4801 Areas that are currently inundated by the Snake River reservoirs will become free-flowing river
4802 sections, although the incoming hydrology may still be regulated by upstream dams where
4803 present. Along the reservoir margins, some higher elevation surfaces will be abandoned and no
4804 longer inundated after the breaching of the dams. These newly exposed surfaces could contain
4805 cultural resources important to tribes that will no longer be protected by inundation from the
4806 reservoirs. Sediment currently stored in the reservoirs will either become part of the new river
4807 and floodplain features, transported downstream, or be left behind on the abandoned margin
4808 surfaces. During dam embankment breaching and in the near term (up to 10 years) following,
4809 sediment loads downstream will be elevated as the Snake River erodes and processes the
4810 sediment deposits behind the dams and residual deposits left on higher terrace surfaces. These
4811 higher sediment loads may affect current tribal access and types of recreation and fisheries use
4812 in the former reservoirs and downstream areas altered from changed sediment conditions.

4813 Over the long term, watershed sediment loads that were historically trapped behind the lower
4814 Snake River Dams will be seasonally routed to the Columbia River where it is expected to
4815 deposit primarily in the upper 10 miles of the McNary Reservoir between the confluence and
4816 Wallula, Washington. Over the long term, the free-flowing river conditions will provide
4817 alternate recreation and fisheries opportunities discussed in other EIS chapters.

4818 **3.4 WATER QUALITY**

4819 The water quality of the Columbia River Basin is affected by many past and present influences,
4820 including human population growth and associated pollutants, water withdrawal for municipal
4821 and industrial water and irrigation (and irrigation return flows), dam structures and operations
4822 (Federal and non-Federal), and land use practices including mining, domesticated livestock,
4823 agriculture, industry (pulp and paper mills), logging (silviculture and forest management), and
4824 recreation (e.g., shoreline erosion). New pollutants are continually being identified, such as
4825 pharmaceuticals (Nielsen et al. 2014); the existing National Pollutant Discharge Elimination
4826 System programs regulate certain identified compounds from point sources, but other
4827 pollutants may also be present and unaccounted for. Nonetheless, surface water in the
4828 Columbia River Basin supports a wide variety of resident and anadromous fish and other
4829 aquatic organisms and wildlife.

4830 The 14 Federal dams within the CRSO study area have affected water and sediment quality due
4831 to the creation of reservoirs throughout the system. Prior to the construction of these and
4832 other dams, the Columbia River and its tributaries were free-flowing, natural rivers. These rivers
4833 experienced seasonal flow and temperature changes. The seasonal peak flows would have
4834 moved sediment downstream over time. Water depths would have been comparatively shallow
4835 (more shallow than the current reservoirs) which has implications for water velocity, water
4836 temperature, and ecological processes. Water in the river was fully mixed as the water flowed
4837 downstream. The river conditions dictated the water and sediment quality, which in turn
4838 dictated the habitat and species found in the habitat.

4839 The Corps and Reclamation constructed the 14 Federal dams in the Columbia River System and
4840 manage the water flowing through the dams for the various authorized purposes. The dam
4841 structures and operations reduce river velocity, dampening the hydrograph relative to the
4842 undammed river condition. The dams interrupt the connectivity of the river, creating a series of
4843 reservoirs that act more like lentic (lake) rather than lotic (riverine) systems, ultimately
4844 changing water quality processes.

4845 In general, large dams have an influence on the riverine ecosystem downstream of the structure
4846 (Ward and Stanford 1983; Nillson and Berggren 2000). Dams alter flow regime, temperature,
4847 oxygen dynamics, sediment dynamics, and channel geomorphology (shape and function)
4848 (Shields et al. 2000; Stanford and Ward 2001). Depending on the mode and pattern of operation,
4849 dams function to reduce frequent peak flows and raise baseflow stage and discharge in the
4850 stream below. Reduction in peak flows acts to decouple a frequent flood or overbank event
4851 from the historical floodplain or riparian zone, which converts a floodplain river to a reservoir
4852 river (flood pulse concept, Junk et al. 1989). When a frequent flood event is decoupled from the
4853 adjacent floodplain, important natural water quality processes and functions are compromised,
4854 including nutrient cycling and transport, contaminant sequestration and sometimes
4855 transformation, carbon export and food chain support, and feeding and breeding opportunities
4856 for aquatic organisms. Because current dam operations are dependent on runoff conditions, in
4857 general, more water is stored and released during high-flow years compared to low-flow years,

4858 resulting in variation in water quality conditions from season to season and year to year. During
4859 periods of high spill resulting in higher downstream velocities, fine sediment can be resuspended
4860 (as wash load) and larger-sized gravel and cobbles are mobilized, which redistributes bedforms
4861 and associated aquatic habitat, may cause accelerated sedimentation, and sometimes removes
4862 established vegetation within the stream channel. In places, shoreline retreat caused by mass
4863 wasting triggered by fluctuating reservoir levels may also occur.

4864 Some reservoirs within the Columbia River Basin stratify. Stratification refers to the different
4865 vertical layers which develop in the water column due predominantly to solar warming of the
4866 surface (top layers) of the water and subsequent changes in the water's density. Generally,
4867 because of this vertical temperature and density gradient, three layers form: epilimnion (top),
4868 metalimnion or thermocline (middle), and hypolimnion (bottom) ([https://www.nwd.usace.
4869 army.mil/CRSO/Documents/](https://www.nwd.usace.army.mil/CRSO/Documents/)). As a result of thermal stratification, water column stability
4870 typically increases and mixing between layers is reduced, isolating various physical and biotic
4871 processes and leading to differences in concentrations of nutrients and other chemicals
4872 between the layers.

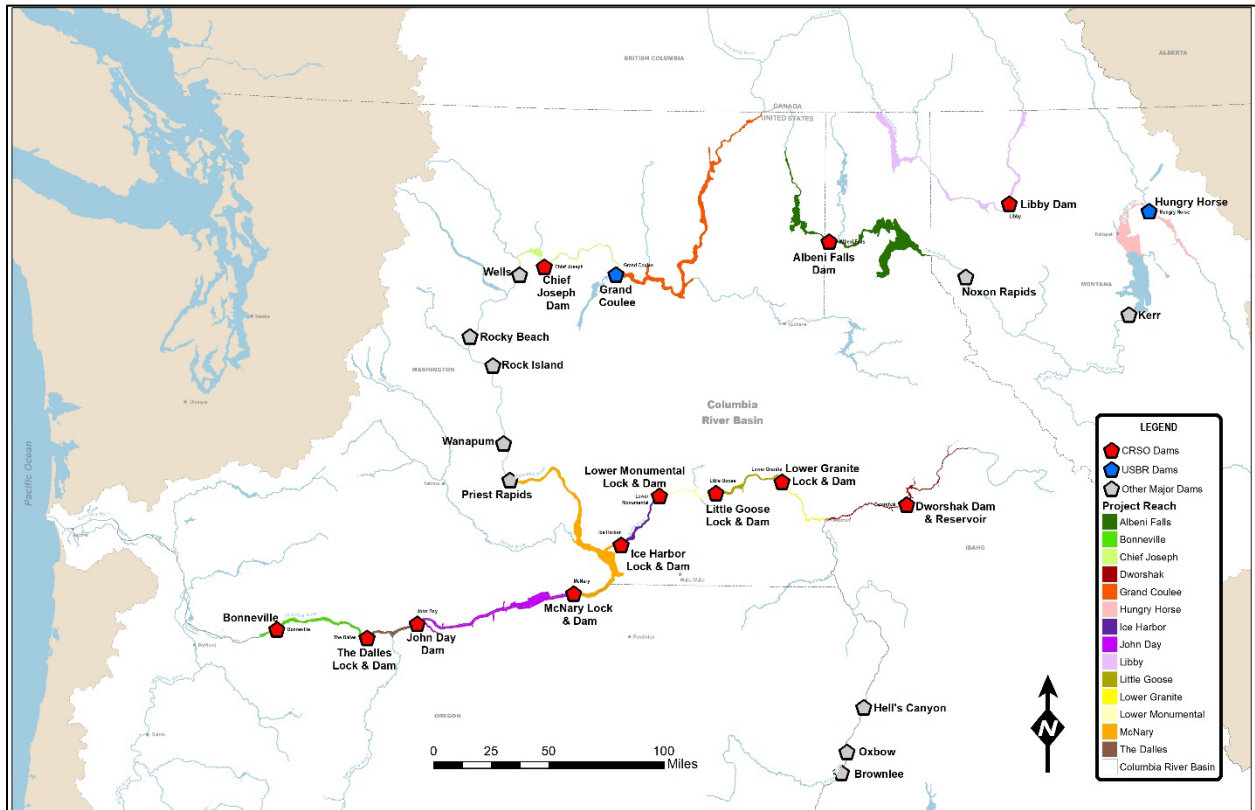
4873 Hungry Horse, Libby, and Dworshak dams have deep storage reservoirs that retain water for
4874 several months, allowing for stratification. This stratification provides the ability to operate
4875 these dams, through selective withdrawal, to support downstream water temperature
4876 objectives. Grand Coulee is also considered a storage project, but it is unique in the fact that it
4877 has relatively low retention times due to the large amount of flow through the reservoir. This
4878 short retention time results in very weak thermal stratification. The other CRS dams (Albeni
4879 Falls, Grand Coulee, Chief Joseph, McNary, John Day, The Dalles, Bonneville, Lower Granite,
4880 Little Goose, Lower Monumental, and Ice Harbor) have relatively short retention times (only a
4881 few days or weeks) and more uniform water temperatures from the surface to the bottom;
4882 selective withdrawal is not useful at these dams since they lack strong stratification.

4883 **3.4.1 Area of Analysis**

4884 The area considered in this water and sediment quality evaluation consists of the Columbia River
4885 and tributaries (Snake, Clearwater, Pend Oreille, Flathead, and Kootenai Rivers) from the U.S.-
4886 Canada border to downstream of Bonneville Dam. This includes the Federal dams of Hungry
4887 Horse, Libby, Albeni Falls, Grand Coulee, Chief Joseph, Dworshak, Lower Granite, Little Goose,
4888 Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville (Figure 3-106).

4889 The water quality analysis for this EIS focused on the area of largest impact both upstream (in
4890 the reservoir) and downstream (in the tailrace) of each CRS dam. Operations of the CRS dams
4891 have negligible impacts on water and sediment quality in the tidally influenced portion of the
4892 Columbia River downstream of Bonneville Dam. These estimates are supported by results that
4893 are described in Sections 3.4.3.3 through 3.4.3.6. The descriptions of water quality and potential
4894 effects in Lake Kooconusa apply to the reservoir in Canada as well as the United States.
4895 Elsewhere in the Canadian portion of the basin downstream of CRS projects, effects to water
4896 quality from the CRSO alternatives would not be expected.

4897 In general, it is known that the dams within the Columbia River basin disrupt the movement of
4898 sediment, blocking most material from moving downstream of Bonneville Dam, except for small
4899 amounts of fine suspended material that are carried to the ocean. It is also recognized that the
4900 presence of the dams may impact the lower Columbia River and estuary, simply because the
4901 natural processes in the river system have been disrupted by the dams; but the effects of dam
4902 construction are not analyzed in this EIS. Other downstream conditions, such as the water and
4903 sediment quality in the Portland, Oregon, area, are affected by factors outside the scope of this
4904 study, and those downstream conditions may also impact these resources. Existing dredging
4905 operations are not considered in this evaluation and are instead covered under other Corps
4906 NEPA documents (Corps 1998, 2002).



4907
4908 **Figure 3-106. Water Quality Study Area Map**
4909 Note: Colored areas represent the study reaches included in this study.

4910 3.4.2 Affected Environment

4911 For this EIS analysis, water quality parameters have been separated into three major categories:
4912 (1) water temperature; (2) total dissolved gas (TDG); and (3) other physical, chemical, and
4913 biological conditions. This information is summarized in the paragraphs below for each MO.

4914 3.4.2.1 Water Quality

4915 The Clean Water Act (CWA) is the primary law governing surface water quality in the United
4916 States with the goal of restoring and maintaining the chemical, physical and biological integrity

4917 of waters (lakes, rivers, streams, wetlands, estuaries and coastal zones) throughout the nation
4918 (33 U.S.C. § 1251 et seq.). Under Section 303(d) of the CWA, the states, territories and
4919 authorized tribes are required to identify and list impaired waters that do not meet these goals
4920 (33 U.S.C. § 1313). The 303(d) list is a report or summary of the impaired waters that are
4921 categorized as a Level 5, meaning that water quality standards have not been met for one or
4922 more pollutants, and there is no total maximum daily load (TMDL) or pollution control program
4923 in place. Multiple waterbodies within the CRSO study area are 303(d) listed. EPA is currently in
4924 the process of developing a temperature TMDL. This is discussed further in Appendix D.

4925 Water quality standards (WQs) are the legal basis for controlling pollutants entering the
4926 waters of the United States. The WQs describe the desired condition of a water body and the
4927 purpose of the condition. The states within the CRSO study area have established their own
4928 WQs and monitoring programs in response to the CWA. Several tribes also have U.S.
4929 Environmental Protection Agency (EPA)-approved water quality standards and monitoring
4930 programs that apply to portions of the river, including the Confederated Tribes of the Colville
4931 Reservation, the Kalispel Tribe of Indians, and Spokane Tribe of Indians. These standards vary
4932 by water body and location and protection for various designated uses. Current (2016) state
4933 and tribal TDG and water temperature standards are used as the metrics to which all MO
4934 analysis results are compared.

4935 TDG saturations¹ in rivers can fluctuate due to a variety of natural and human-caused
4936 influences. Natural influences include total flow, wind, air temperature, barometric pressure,
4937 and incoming TDG from upstream and tributaries. TDG saturation can also increase when dams
4938 release water through spillways and other non-turbine outlets. Spilling water at a dam results in
4939 increased TDG levels in downstream waters by plunging the aerated spill water to depths
4940 where hydrostatic pressure increases the solubility of atmospheric gases. Elevated TDG
4941 saturations generated by spill releases from dams are of concern because high saturations can
4942 promote the potential for gas bubble trauma in downstream aquatic biota (Weitkamp and Katz
4943 1980; Weitkamp et al. 2002).

4944 Spill operations may be necessary at individual CRS projects in circumstances when river flows
4945 exceed powerhouse hydraulic capacity, turbine outages occur, when powerhouse capacity is
4946 available but there is no demand for the additional electricity, or when North American Electric
4947 Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) requirements
4948 apply. These events may limit the co-lead agencies' ability to pass water through the
4949 powerhouse and, in some cases, may result in additional spill, which can impact TDG levels. The
4950 state and tribal water quality standards for TDG are 110 percent throughout the Columbia River
4951 Basin. To date, the states of Oregon and Washington have provided either standard
4952 modifications or criteria adjustments on a short-term basis for the benefit of juvenile fish that
4953 are passing the lower four Snake River and lower four Columbia River projects during the
4954 juvenile fish passage spill season, which runs from April through August. During this season, the
4955 lower eight dams are operated in accordance with applicable biological opinions and within

¹ TDG levels are measured at specific gages throughout the CRS and are representative of the TDG levels in the rivers.

4956 these modified TDG standards. The state and tribal water quality standards for TDG are 110
4957 percent throughout the Columbia River Basin with the exception of the lower four Snake River
4958 and lower four Columbia River projects during the juvenile fish passage spill season, which runs
4959 from April through August. During the juvenile fish passage spill season, the lower eight dams
4960 are operated in accordance with applicable biological opinions to meet modified TDG
4961 standards.²

4962 Water temperature is one of the most important physiochemical constituents of surface water
4963 and has been modeled as part of the CRS EIS analysis. It controls the rate of all chemical
4964 reactions, directly affects fish and benthic macroinvertebrate growth and reproduction, and can
4965 be acutely toxic (fatal) to fish if drastic temperature changes occur or if temperatures exceed
4966 25°C for salmon and steelhead.

4967 Water temperatures in many reaches do not meet the regulatory standards in the summer and
4968 early fall. System operations can impact both water temperature and TDG in the Columbia River
4969 Basin, and given this the impact, the analysis in the CRSO EIS focuses on how both parameters
4970 may change with a change in operation as described in the MOs as compared to the No Action
4971 Alternative.

4972 **WATER TEMPERATURE**

4973 Hungry Horse Dam is outfitted with a selective withdrawal system (SWS) that allows water to be
4974 drawn from various elevations in the reservoir to meet downstream water temperature
4975 objectives. The SWS can operate over a pool elevation range from full (3,560 feet) down 160 feet
4976 (3,400 feet). However, major modification to the structure(s) is required to enable function over
4977 the lower 60 feet of this range, including removal of the upper and intermediate stationary gates.

4978 The SWS at Hungry Horse Dam is operated from approximately June through October to release
4979 warmer water, to mimic temperatures similar to those in the Middle and North Fork Flathead
4980 Rivers. During winter and spring months, the reservoir's water column is well mixed, with
4981 temperatures throughout the water column being nearly equal from top to bottom
4982 (isothermal), making selective withdrawal operations ineffective.

4983 Lake Koochanusa is the 90-mile-long reservoir formed by Libby Dam. The thermal conditions in
4984 Lake Koochanusa at Libby Dam typically lag seasonal weather conditions by several months due
4985 to the long residence time and thermal inertia (massive volume of water that slows warming
4986 and cooling within the reservoir). The heat contained in the reservoir during the summer is
4987 carried over into the fall and winter months. In general, thermal conditions at Libby Dam
4988 typically reach minimum temperatures during late March or early April and are characterized by
4989 a uniform temperature near 39.2°F (4°C). However, during cold winters surface water

² The Corps managed to 120 percent and 115 percent (the Washington TDG standard) in 2016, at the time of the Notice of Intent to Prepare the EIS. It should be noted that both Oregon and Washington have begun a water quality standards change process during 2019 for juvenile fish passage spill up to 125 percent TDG in the tailrace during the spring juvenile downstream fish passage season; however, the summer juvenile fish passage spill TDG standard will not change.

4990 temperatures can be in the low 30s°F (0°C to 2°C) range, with surface icing occurring on the
4991 shallower upper half of the reservoir. Historical data suggests that the onset of thermal
4992 stratification typically begins in late April and May, and is weak and often short lived as weather
4993 systems disrupt the thermal structure. Full reservoir mixing and isothermal conditions (i.e.,
4994 thermal destratification from the loss of heat, at the surface of the lake, back to the
4995 atmosphere) generally begins in December.

4996 Libby Dam was designed with a selective withdrawal system (SWS) to manage release water
4997 temperatures downstream in the Kootenai River when thermal stratification develops in the
4998 reservoir. The selective withdrawal system is operated to provide as close to natural water
4999 temperatures as possible downstream in the Kootenai River throughout the year. However,
5000 given the presence of a large deep reservoir with stored latent heat as the source of water to
5001 the river, outflow temperatures can be cooler in the spring and warmer in the late fall
5002 compared to the natural pre-dam Kootenai River. Given this, the selective withdrawal system is
5003 operated to follow as best as possible a temperature rule curve developed from pre-dam daily
5004 temperatures collected in the Kootenai River from 1967 to 1972 by the Corps and Montana
5005 Fish, Wildlife & Parks.

5006 Albeni Falls Dam is located in northern Idaho on the Pend Oreille River about 28 miles
5007 downstream of Lake Pend Oreille. Although Lake Pend Oreille is a natural lake, Albeni Falls Dam
5008 regulates the upper 11.5 feet of the lake. Albeni Falls Dam has little ability to manage water
5009 temperatures in the Pend Oreille River, and water temperature changes in Lake Pend Oreille
5010 and the Pend Oreille River are mainly influenced by atmospheric conditions and weather
5011 patterns. Lake Pend Oreille is the fifth deepest lake in the United States and exhibits strong
5012 thermal stratification regardless of the runoff year. However, a shallow low-water outlet
5013 channel acts as a barrier to the transport of much colder deep water from Lake Pend Oreille
5014 into the Pend Oreille River resulting in warmer lake surface waters entering the river. The Pend
5015 Oreille River TMDL (2011 revised) addresses elevated water temperatures in the summer.
5016 Winter water temperatures can be in the low 30s°F (0°C to 2°C) range, with some surface icing
5017 during colder winters.

5018 At Grand Coulee Dam, there is little opportunity to manage downstream water temperatures as
5019 Lake Roosevelt is weakly stratified. This results in Grand Coulee releasing the coolest water
5020 possible in the summer months, based on constraints for generation reliability, voltage stability,
5021 and TDG standards. Because of the weak stratification, discharged water temperatures lag the
5022 warming/cooling trends observed in the inflow, at the U.S.-Canada border, and tend to be
5023 cooler in the spring and warmer in the fall than inflowing conditions. Portions of Lake Roosevelt
5024 is currently listed as a Category 5 reach on the state of Washington's 303(d) list for
5025 temperature.

5026 Chief Joseph Dam is a run-of-river project located downstream of Grand Coulee Dam. Rufus
5027 Woods Lake, the 50-mile-long reservoir formed by Chief Joseph Dam, has an average water
5028 retention time (the amount of time water remains in the reservoir) ranging from about 1 to 8
5029 days. Little to no thermal stratification occurs in Rufus Woods Lake, and water temperatures

5030 released from Grand Coulee Dam are passed downstream with little change due to the high
5031 flows and short retention time in the reservoir. In general, historical hourly temperatures are
5032 greater than 60.8°F (16°C) from about the middle of July through late October, and greater than
5033 63.5°F (17.5°C) from about the beginning of August through the end of September. Rufus
5034 Woods Lake falls under the state of Washington's 303(d) list Category 5 for temperature due to
5035 high water temperatures in the late summer.

5036 Dworshak is a deep, cold-water reservoir that exhibits strong thermal stratification regardless
5037 of the runoff year. Summer releases from the project are used to reduce water temperatures
5038 downstream in the lower Snake River (Lower Granite, Little Goose, Lower Monumental, and Ice
5039 Harbor Dams) where temperatures historically exceeded the current state of Washington
5040 standard of 68°F (20°C), even before the dams were constructed (Corps 2002). Historical
5041 temperatures in the lower Snake River Basin prior to the construction of the lower Snake River
5042 dams and the Hells Canyon Complex show that temperatures in the free-flowing lower Snake
5043 River often exceeded 68°F (20°C) in July and August and occasionally exceeded 25°C. These
5044 measurements were taken near the mouth of the Snake River from 1955 to 1958 (Peery and
5045 Bjornn 2002). The most noticeable effect can be seen at Lower Granite Reservoir where the
5046 tailwater water temperatures are managed to meet, or be less than, the state water quality
5047 standard during the summer. The cooling effect in the lower Snake River diminishes at each
5048 successive downstream reservoir and the frequency of exceedances above the standard
5049 increases. Winter water temperatures are typically in the low 30s°F (0 to 2°C) range, with some
5050 surface icing during colder winters.

5051 The four lower Columbia River reservoirs (McNary, John Day, The Dalles, and Bonneville) are on
5052 the state of Washington's and Oregon's 303(d) due to elevated water temperatures above the
5053 standard of 68°F (20°C). All four reservoirs show weak to no surface warming during the
5054 summer months, largely due to the short residence time, wind, and flow-induced turbulent
5055 diffusion and convective mixing that occur in the reservoirs. The management of water
5056 temperatures in a manner similar to the strategies used on the lower Snake River is not
5057 effective in the lower Columbia River because there is not an upstream source of very cold
5058 water. Therefore, access to off-channel thermal refugia is critical for the migration and
5059 spawning success of anadromous fish (EPA 2020).

5060 **TOTAL DISSOLVED GAS**

5061 Libby and Hungry Horse Dams are both considered high head (tall) dams that tend to generate
5062 elevated TDG even when small discharges are released through the dams' non-turbine outlets.
5063 Spill at Libby is infrequent, so TDG exceedances are not as commonly seen as in other parts of
5064 the CRSO study area. Spill occurs more frequently at Hungry Horse as compared to Libby.

5065 TDG on the South Fork Flathead River downstream of Hungry Horse Dam, to the confluence
5066 with the mainstem Flathead River, is of concern for resident fish species. When outflows
5067 exceed powerplant capacity, flows must be spilled through the outlet works (hollow-jet valves)
5068 or the spillway, which results in supersaturated gases in the downstream river. Based on the
5069 level of saturation and the length of exposure, effects can be acute or chronic and may result in

5070 mortality of fish in the system (Monk 1997). In high-flow years, TDG often does not meet the
5071 state standard of 110 percent below the dam during the spring and early summer due to the
5072 release of large amounts of water through outlets known to produce TDG.

5073 In any given year, additional outages can occur due to regulatory requirements, planned
5074 maintenance, or unexpected events/equipment failures, which may limit the ability to pass
5075 water through the powerhouse and, in some cases, may result in additional spill. Specifically,
5076 Reclamation is planning a Hungry Horse Powerplant Modernization and Overhaul Project in the
5077 next 10 years (Reclamation 2018). Maintenance would require outages for one year in the
5078 powerplant, limiting the powerplant to two units and reducing the hydraulic capacity to
5079 approximately 6 kcfs. This could result in additional spill in this 1 year.

5080 Spillway flows from Libby Dam can impact TDG saturations downstream in the Kootenai River.
5081 Spillway releases can result in an abrupt increase in TDG to saturations greater than 120
5082 percent. However, in contrast to Hungry Horse Dam, the Libby Dam spillway is operated less
5083 frequently. Given this, downstream TDG saturations are less than 110 percent the majority of
5084 the time.

5085 Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills
5086 most years. In general, spillway operations between 1 to 50 kcfs at Albeni Falls Dam increase
5087 downstream TDG saturations by about 0 to 9 percent of forebay saturation depending on the
5088 amount of water spilled, the number of spillway bays operating, forebay TDG saturations, and
5089 total head. When spill is greater than about 50 to 60 kcfs powerhouse operations are
5090 suspended and the spill gates are opened, allowing the river to flow relatively unimpeded
5091 across the dam. Under these free-flow conditions there is little to no increase in downstream
5092 TDG saturations.

5093 Spill at Grand Coulee Dam occurs when total flows exceed powerhouse capacity during high
5094 flows typically observed in the spring and early summer. Spill can also occur during lack of
5095 market conditions when there is no demand for additional electricity and hydropower
5096 production is unnecessary. Often in high-flow years water flowing into Lake Roosevelt across
5097 the U.S.-Canada border is in excess of 110 percent TDG. When Grand Coulee is required to spill
5098 to achieve flow or flood risk management (FRM) elevation requirements spill can exceed 130
5099 percent TDG in some cases. The outlet tubes, and to a lesser extent, the drum gates, at Grand
5100 Coulee Dam are known to produce elevated TDG when in operation. When reservoir elevations
5101 are greater than 1,266 feet, the 11 drum gates can be used to discharge water downstream.
5102 The drum gates generate much less TDG than the outlet tubes and are the preferred outlet
5103 when available. The 40 regulating outlets are used to discharge water downstream when the
5104 forebay elevation is below 1,266 feet, at which point the drum gates become inoperable.

5105 Spill at Chief Joseph Dam is also highly dependent on runoff volume and hydropower
5106 operations. Spill can also occur during lack of market conditions when there is no demand for
5107 additional electricity. The spillway is equipped with spillway deflectors to reduce TDG loadings
5108 to the Columbia River. Spilling at Chief Joseph Dam, when incoming TDG levels are elevated
5109 (greater than 120 percent), can reduce system TDG loading, therefore Chief Joseph Dam can be

5110 used to manage TDG saturations in the Columbia River. In general, spill at Chief Joseph Dam
5111 results in tailwater TDG saturations ranging from about 110 to 120 percent.

5112 Dworshak Dam operations typically produce TDG that is less than 110 percent the majority of
5113 the time. Short-term exceptions, however, do occur when additional water is released for FRM
5114 purposes.

5115 The four lower Snake River dams are run-of-river projects and TDG production is highly related
5116 to runoff volume and water temperature as documented in the TMDL for Lower Snake River
5117 Total Dissolved Gas (Washington State Department of Ecology [Ecology] 2003). The state of
5118 Washington has issued a short-term criteria adjustment to its TDG water quality standard to
5119 not exceed a 12-hour average TDG of 115 percent in the forebay and 120 percent in the
5120 tailwater for the purpose of juvenile fish passage during the juvenile fish spill season (generally
5121 April through August³). Excursions above these thresholds can occur, but are relatively
5122 infrequent due to the spillway deflectors and project operations (e.g., spill pattern and amount
5123 of spill) that are monitored and adjusted daily. Additionally, TDG saturation can be elevated not
5124 only during high-flow periods such as spring runoff, but also during low-flow conditions when
5125 the air temperatures are high.

5126 The four lower Columbia River dams are operated for downstream fish passage during the fish
5127 passage spill season (April to August). These spill operations are managed to keep TDG
5128 saturation levels at or below modified/adjusted state water quality standards for the states of
5129 Washington (see above) and Oregon of 120 percent in the downstream tailwater. For the most
5130 part, TDG exceedances above these thresholds are minimal during the juvenile fish passage
5131 season, which can be attributed to structural enhancements (e.g., spillway deflectors) and
5132 operational strategies (e.g., tailoring spill to the configuration of each dam and its associated
5133 bathymetry, limiting spill, implementing spill patterns) that have been implemented over the
5134 years. Nonetheless, exceedances of the standards do occur under some river and
5135 meteorological conditions and there is a TDG TMDL that covers all four lower Columbia River
5136 reservoirs (Ecology 2002).

5137 **OTHER PHYSICAL, CHEMICAL, AND BIOLOGICAL PROCESSES**

5138 Hungry Horse Reservoir is considered oligotrophic, meaning it has low concentrations of
5139 nutrients required for primary productivity, but is well oxygenated throughout the water
5140 column. Due to low food availability (productivity) in the reservoir, resident fish rely on
5141 terrestrial insects near the lake's shore to supplement their diet. Pollutants tend to be relatively
5142 low in the Hungry Horse Reservoir and no known pollution problems exist in the reservoir.

5143 Lake Kocanusa would be classified as an oligotrophic to lower mesotrophic (intermediate
5144 concentrations of nutrients) water body based on summer concentrations of total phosphorus,
5145 chlorophyll a, and transparency (turbidity). The reservoir experiences weak thermal
5146 stratification and is well oxygenated throughout the entire water column. Total phosphorus

³ *Supra* note 8.

5147 concentrations are low and follow a seasonal pattern of increasing during spring runoff and
5148 decreasing during the summer and fall. Total phosphorus concentrations are typically two to
5149 five times greater at the U.S.-Canada border compared to the forebay, suggesting that Lake
5150 Koochanusa acts as a phosphorus sink. Concentrations of nitrate have been increasing
5151 throughout Lake Koochanusa since the early 2000s. The major change in the Lake Koochanusa
5152 watershed since 2000 is an increase in coal mining operations in the Elk and Fording Rivers
5153 watershed in British Columbia, and a corresponding increase in nitrate loading from the waste
5154 spoils runoff. Estimates are that the total amount of waste spoils from coal mining operations in
5155 British Columbia increased tenfold from 1997 to 2016. In addition, USGS has estimated that
5156 increased coal mining in the Elk and Fording Rivers has increased selenium loading to Lake
5157 Koochanusa fivefold over the past 20 years (USGS 2014). In general, total selenium
5158 concentrations are greatest in the hypolimnion. There does not appear to be a substantial
5159 seasonal trend in the data, but concentrations are generally higher in the spring and fall and
5160 lower in the summer.

5161 For both Lake Pend Oreille and the Pend Oreille River, in general, summer total phosphorus and
5162 nitrate concentrations are low, water clarity is high, and algal growth is moderate. The lake and
5163 river are well oxygenated throughout the water column. A nearshore TMDL for nutrients was
5164 developed for Lake Pend Oreille in 2002 in response to an increasing trend in nuisance algal
5165 growth in the nearshore areas (IDEQ 2015).

5166 Lake Roosevelt is classified as oligotrophic based on chlorophyll a, total nitrogen, total
5167 phosphorus, and Secchi depth measurements; however, some variation of this classification
5168 does exist both spatially and temporally. One example includes the area of reservoir at the
5169 mouth of the Spokane River, which is considered mesotrophic due to the influence of the
5170 nutrient-rich Spokane River. The increase in primary productivity due to this nutrient load tends
5171 to be localized and does not cause widespread issues for fish.

5172 Historically, pollution from mining and smelting, as well as the atmospheric deposition of
5173 mercury, has impacted water quality in Lake Roosevelt. Metals have contaminated bed
5174 sediments, and mercury cycling—the process that converts insoluble mercury in the sediment
5175 and water into a soluble form (methylmercury)—has become more of a concern. The presence
5176 of these pollutants has contributed to fish consumption advisories due to bioaccumulation.
5177 These pollutants have likely migrated downstream through Lake Roosevelt. Trace elements
5178 have been found in Rufus Woods Lake sediments, suggesting that high flow events may push
5179 metal contaminants past Grand Coulee Dam at times (<https://www.nwd.usace.army.mil/CRSO/Documents/>). Additionally, dioxin discharge from pulp and paper mills and other sources
5180 has occurred in the system. EPA issued a TMDL for dioxin from RM 0 to RM 745 (below Grand
5181 Coulee Dam) in 1991, as well as for portions of the Snake River.
5182

5183 Rufus Woods Lake is a well-oxygenated near neutral to slightly basic pH waterbody with low to
5184 moderate nutrient concentrations. Small increases in total phosphorus and ammonia
5185 concentrations measured downstream of aquaculture facilities in Rufus Woods Lake suggest
5186 that these facilities may be a source of these nutrients. Rufus Woods Lake experiences annual

5187 harmful algae blooms (HABs) consisting of free-floating surface mats or clumps of algae
5188 containing the cyanobacteria *Oscillatoria* and the cyanotoxin anatoxin-a, which is a neurotoxin
5189 that can cause severe illness or death in animals and humans if ingested. These mats of algae
5190 are found throughout Rufus Woods Lake upstream and downstream of the aquaculture
5191 facilities. The increase in HABs is not attributed to the aquaculture facilities. These blooms are a
5192 fairly recent water quality issue, and remain unexplained, although HABs are typically caused by
5193 excess nutrient loads and enhanced by increased stream and air temperatures. Blooms also
5194 occasionally form in other areas of the Columbia, particularly in backwaters. There was a
5195 documented exposure (rash) for workers in contact with HABs on the Columbia in Grant County
5196 in 2009, for example (Ecology 2009).

5197 Dworshak is a long, relatively narrow reservoir with historically low nutrient concentrations. A
5198 lake fertilization project began in 2007 with the goal of increasing productivity by changing the
5199 nitrogen to phosphorus ratios in the reservoir, thereby promoting the growth of phytoplankton
5200 species that are edible by zooplankton, resulting in improved forage base for fish. Some
5201 changes, both increases and decreases, have been documented for several of the chemical and
5202 biological parameters that are being monitored under the current lake fertilization project
5203 (<https://www.nwd.usace.army.mil/CRSO/Documents/>). Many of these changes have occurred
5204 in areas that are fertilized, as well as reaches that are not fertilized. As the program continues,
5205 additional data should help identify whether the observed shifts are due to the fertilization
5206 program, changes related to the inflows, natural aging of the lake, or other unidentified causes.

5207 The water quality characteristics of the lower Snake River are, to a large extent, influenced by
5208 the inflowing Snake River above the confluence with the Clearwater River. The concentrations
5209 of soluble ions and nutrients are lowest during high runoff events when suspended solids are
5210 highest. There are usually no significant differences in the concentrations of these constituents,
5211 as well as chlorophyll a and algal biovolume, from one reservoir to the next. This is likely due to
5212 the relatively short hydrologic residence time of each impoundment.

5213 Within the lower Columbia River, information on other water quality issues is limited. High pH
5214 and/or dissolved oxygen in limited portions of the reach from The Dalles to Bonneville Dams
5215 resulted in the inclusion of these parameters in the Washington or Oregon 303(d) lists for those
5216 stretches. Additionally, some portion of all four reservoirs contain other water quality
5217 impairments (mercury and polychlorinated biphenyls [PCBs] have fish consumption advisories
5218 and are on 303(d) lists; dioxin has a TMDL). The lower Columbia River contains a wide variety of
5219 human-sourced compounds, including metals and organic compounds. Continued pollutant and
5220 nutrient loading is expected due to farming activities, industry, and urban and agricultural
5221 runoff.

5222 **3.4.2.2 Sediment Quality**

5223 Sediment in the Columbia River Basin is variable in size and composition. Within rivers,
5224 sediment originates in the upland areas and riverbanks, as erosion and materials washed or
5225 discharged into the river. Coarse-grained material (rock, stone, coarse sand) settles and moves
5226 only with the highest flows. Finer-grained material (clay, silt) tends to wash further down the

5227 river. In all cases, when the water slows or stops, such as in large reservoirs behind dams, the
5228 solids washed along by the water settle out and become the sediment at the bottom of the
5229 river.

5230 Sediment in some areas impedes use of tribal fishing access sites and has negative impacts on
5231 cold-water refuges and other important habitat. Sedimentation can also impact navigation
5232 when it builds up in shipping channels. Areas commonly dredged include the confluence of the
5233 Snake and Clearwater Rivers, and other navigation points such as lock approaches and docking
5234 areas. The Corps maintains the navigation channel by dredging and by other activities, such as
5235 those listed in the Programmatic Sediment Management Plan (Corps 2014) and other
5236 documents. Sediment is characterized following applicable guidance and regulations prior to
5237 the implementation of dredging projects.

5238 Sediment can carry pollutants. Naturally occurring metals (e.g., mercury) are expected to be
5239 present in the sediment, but unnaturally high levels of metals, nutrients, or organic compounds
5240 that wash into the river can bind to the sediment and remain at the bottom of the river. These
5241 pollutants can be mixed back into the water at a later time when the sediment is disturbed, or
5242 they can remain in the river or reservoir and impact aquatic organisms that live in or near the
5243 sediment.

5244 Within the Columbia River Basin, sediment quality varies by location. The uppermost end of the
5245 system, such as the area near Hungry Horse Dam, tends to have fewer human influences and
5246 thus less sediment-based pollution. As one moves downstream to more populous areas,
5247 sediment pollution is more common. In addition, some reservoirs have known sediment
5248 pollution problems related to past industrial discharges from upriver sources. For example, in
5249 Lake Roosevelt, an estimated 10 to 14 million tons of slag-related contaminants are can be
5250 found in the sediments due to smelter operations. Sediment does not easily wash away from
5251 reservoirs, and the quality of the sediment tends to reflect the land uses and past
5252 environmental practices of the land users.

5253 General issues throughout the Columbia River Basin include metals, which are particularly high
5254 in some reservoirs, and pesticides. Pesticides are generally present in low concentrations,
5255 however many of these compounds are toxic to aquatic organisms, bioaccumulate, and persist
5256 in the environment for decades. Other notable pollutants found in sediment within the basin
5257 include radionuclides, dioxins, and petroleum-based compounds. As with water pollutants, the
5258 sediment pollutants reflect the land uses and practices within the basin, including urban
5259 development, agriculture, mining, and other industrial activities. In summary, the contaminants
5260 of concern in sediment include metals, mercury, PCBs, dioxins, pesticides, and other organic
5261 compounds (mostly from human sources). Sediment quality at individual reservoirs, including
5262 potential sources of pollutants and historical issues, is discussed at length in separate technical
5263 documents that can be found on the CRSO website
5264 (<https://www.nwd.usace.army.mil/CRSO/Documents/>).

5265 **3.4.3 Environmental Consequences**

5266 **3.4.3.1 Methodology**

5267 Changes to water and sediment quality for each alternative were assessed using both
5268 quantitative (numerical) and qualitative methods. Modeling was used to simulate the effects on
5269 water temperature and TDG in the Columbia, Snake, and Clearwater River Systems, while
5270 qualitative methods were used to predict effects to other physical, chemical, and biological
5271 processes such as dissolved oxygen.

5272 The analysis used the CE-QUAL W2 and Hydraulic Engineering Center River Analysis System
5273 software (HEC-RAS) numerical models which are described further below:

- 5274 • CE-QUAL-W2 model: The CE-QUAL-W2 model (Version 4.2) was used to simulate reservoir
5275 water temperature and TDG both by depth and distance up and downstream.
- 5276 • HEC-RAS model: The HEC-RAS model (Version 5.0.3) was used to simulate up and
5277 downstream river (non-reservoir) water temperatures in the Snake, Clearwater, and middle
5278 Columbia Rivers.

5279 Portions of the study area were analyzed with the CE-QUAL W2 and HEC-RAS models linked
5280 together. This is referred to as the “system model.” The portion of the CRSO study area
5281 considered in the system model included an area that extended from the Columbia River
5282 mainstem at the U.S.-Canada border to Bonneville Dam. In the Snake River Basin, the system
5283 model included the North Fork of the Clearwater River from Dworshak Reservoir, the mainstem
5284 Clearwater River downstream of Orofino, Idaho, and the Snake River from Anatone,
5285 Washington, to the mouth of the Snake River. The system model included the 11 Federal dams
5286 in the study area: Grand Coulee, Chief Joseph, Dworshak, Lower Granite, Little Goose, Lower
5287 Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. It also included five
5288 non-CRS projects (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids) on the
5289 Columbia River mainstem to more accurately describe the river conditions (Figure 3-107);
5290 however, the water quality at the non-CRS dams is not discussed in this section.

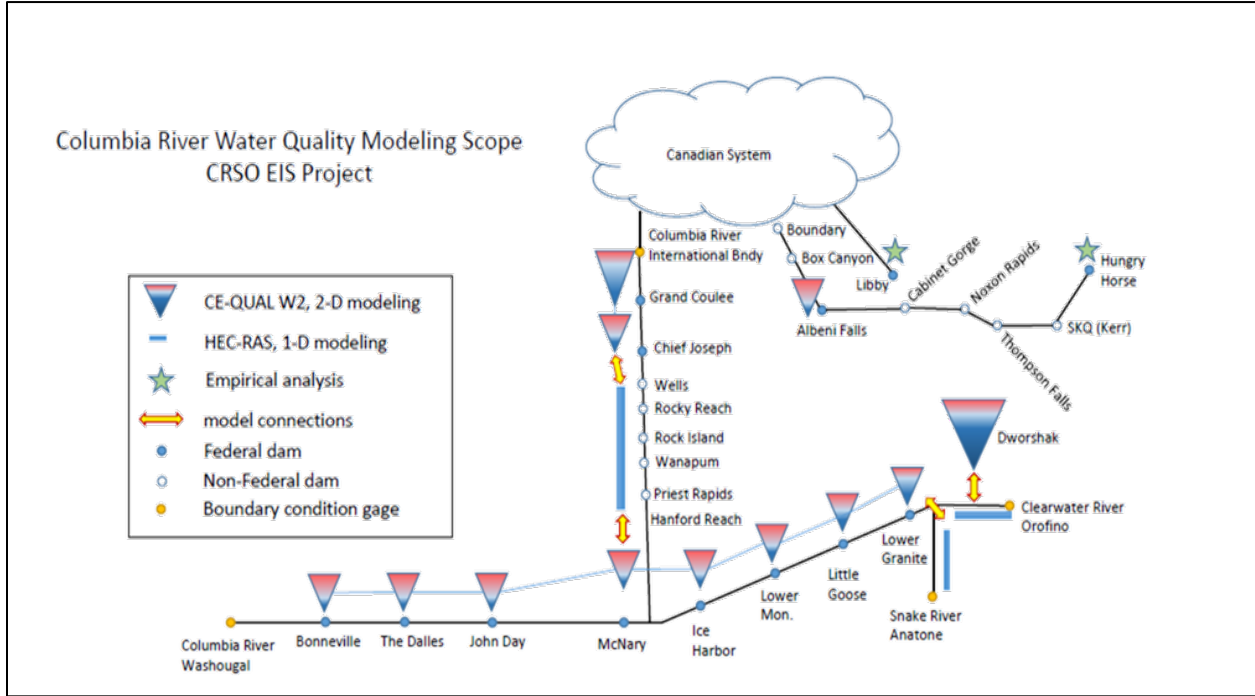
5291 The system model required reservoir and river operations data and meteorological data such as
5292 wind speed and direction, air temperature, and barometric pressure inputs to predict water
5293 quality conditions. The reservoir and river operations data⁴ used in the system model included
5294 total discharge, spillway and powerhouse operations, miscellaneous discharge, and
5295 reservoir/tailwater elevation data.

5296 Water quality modeling in the system model was conducted over a 5-year period (2011 to
5297 2015) to represent a wide range of environmental responses to hydrology (wet, dry, average)
5298 and weather conditions (hot, cold, average). These years are represented as the following:

- 5299 • 2011 = HF/LT (high inflow/low temperature),

⁴ Reservoir and river operations data were derived from the H&H ResSim and HydSim models, as described in Section 3.2.

- 5300 • 2012 = AF/LT (average inflow/low temperature),
- 5301 • 2013 = LF/AT (low flow/average temperature),
- 5302 • 2014 = AF/AT (average flow/average temperature), and
- 5303 • 2015 = LF/HT (low flow/high temperature).



5304
5305 **Figure 3-107. Columbia River System Operations Environmental Impact Statement Water**
5306 **Quality Modeling Framework**

5307 After running the system model, the simulated water temperature and TDG data were
5308 compared to state, federal and tribal temperature and TDG standards to quantify the effects
5309 associated with each alternative. This information was also used to inform effects to other
5310 resources such as anadromous and resident fish (Section 3.5), wildlife (Section 3.6), tribal uses
5311 (Section 3.17), and recreation (Section 3.11).

5312 To analyze effects associated with actions at Albeni Falls Dam, the CE-QUAL W2 model was run
5313 separately from the system model because the Albeni Falls Dam is located on the Pend Oreille
5314 River approximately 100 river miles upstream from where the Pend Oreille River joins the
5315 Columbia River. Moreover, downstream of the Albeni Falls Dam, the Pend Oreille River is
5316 influenced by two non-Federal U.S. dams and two Canadian dams before flowing into the
5317 Columbia River. The Albeni Falls water quality modeling was used to simulate effects from the
5318 operation of Albeni Falls Dam, only, and not effects from the operation of non-CRS dams such
5319 as Boundary or Box Canyon, which fall outside the scope of this EIS. The Albeni Falls modeling
5320 addressed the area that extends from the outlet of Lake Pend Oreille near Sandpoint, Idaho,
5321 downstream to Albeni Falls Dam. The model simulated water temperatures, which were
5322 compared to state and Federal temperature standards. TDG production at Albeni Falls Dam was

5323 addressed qualitatively because a reliable model could not be developed due to a lack of direct
5324 relationship between discharge from the dam and TDG.⁵

5325 For the Libby and Hungry Horse Dams, updated and peer-reviewed CE-QUAL W2 models either
5326 did not exist or were too outdated to be updated for use in this EIS. Instead, analysis tools that
5327 relied on observational data were developed to predict TDG generation from dam operations.
5328 The TDG analysis used TDG production equations that were derived from observational data to
5329 predict TDG generated under the various flow regimes for each alternative. A qualitative
5330 assessment was used to evaluate whether the MOs would likely adversely impact the ability to
5331 continue managing downstream water temperatures using the selective withdrawal systems
5332 that exist at both Libby and Hungry Horse Dams.

5333 For each of the regions in the study area, sediment quality effects were evaluated qualitatively,
5334 using existing field data and information from past studies (white paper; i.e., CH9). There was
5335 no overall model describing sediment quality; however, sediment movement information from
5336 Section 3.3, *River Mechanics*, and the associated white paper; i.e., CH9 were used to inform the
5337 sediment quality analysis. For more information on these models and geomorphology and
5338 analysis, refer to Appendix D, *Water and Sediment Quality Appendix*, and Appendix C, *River
5339 Mechanics Technical Appendix*.

5340 **3.4.3.2 Impact Framework**

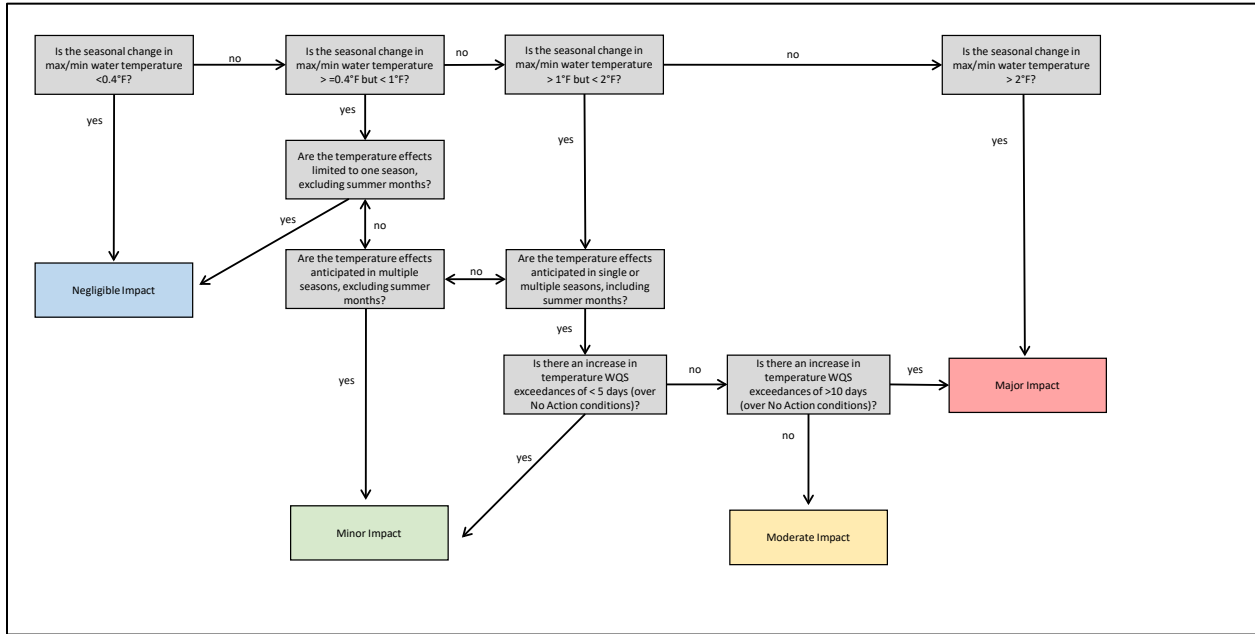
5341 A framework was developed to define the overall level of water temperature and TDG impact
5342 for each CRSO EIS alternative as compared to the No Action Alternative. For water
5343 temperature, the level of impact (negligible, minor, moderate, or major) was defined based on
5344 the absolute change in the maximum and minimum water temperatures as averaged over the
5345 5-year simulation period (2011-2015). If the absolute change in water temperature between
5346 the MO Alternative and No Action Alternative was less than 0.4 degree Fahrenheit, the water
5347 temperature impact was considered negligible. If the absolute change in average minimum and
5348 maximum values was greater than 0.4 degree Fahrenheit, but less than 2 degrees Fahrenheit ,
5349 the impact was considered negligible, minor or moderate based on the time of year (season)
5350 the impact occurred and whether the impact increased the number of days that State water
5351 quality standard (WQS) criteria was not met and by how much. Absolute water temperature
5352 changes of >2 degrees Fahrenheit, or an increase in water temperature WQS exceedances of
5353 greater than 10 days, were considered a major impact (Figure 3-108).

5354 For total dissolved gas, the following decision criteria was used to determine level of impact:

- 5355 • Negligible: <=1% change in the 5-year average maximum TDG as compared to the No Action
5356 Alternative.
- 5357 • Minor: >=1% but <2% change in the 5-year average maximum TDG as compared to the No
5358 Action Alternative.

⁵ Studies indicate that a direct relationship between spillway discharge and the amount of TDG in the water is not consistently observed at Albeni Falls (Schneider et al. 2007). Developing a reliable model to estimate TDG saturations in the Pend Oreille River downstream of Albeni Falls Dam was not possible because of this lack of a spillway discharge versus TDG production relationship.

- 5359 • Moderate: $\geq 2\%$ but $< 3\%$ change in the 5-year average maximum TDG as compared to the
- 5360 No Action Alternative.
- 5361 • Major: $\geq 3\%$ change in the 5-year average maximum TDG as compared to the No Action
- 5362 Alternative.



5363
5364 **Figure 3-108. Water Temperature Impact Framework and Decision Criteria**

5365 These descriptors are used to summarize the overall impact of each EIS Alternative as described
5366 in the sections below.

5367 For more detailed results, please refer to the Water Quality Technical Appendix D.

5368 **3.4.3.3 No Action Alternative**

5369 Water and sediment quality under the No Action Alternative would be expected to continue in
5370 a similar manner as that described in Section 3.4.2, *Water Quality Affected Environment*.

5371 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

5372 **Water Quality**

5373 **Water Temperature**

5374 In Region A, the use of the SWS at Hungry Horse and Libby Dams would continue under the No
5375 Action Alternative and, therefore, water temperatures at both projects are expected to be
5376 similar to those described in the Affected Environment (Section 3.4.2). Water temperatures in
5377 Lake Pend Oreille and the Pend Oreille River would remain unchanged and would also reflect
5378 conditions as described in the Affected Environment.

5379 **Total Dissolved Gas**

5380 TDG often does not meet the state of Montana’s standard of 110 percent below Hungry Horse
5381 Dam during high-flow years when flow exceeds powerhouse capacity and water is released
5382 through the dam outlets known to produce TDG. This is expected to continue under the No
5383 Action Alternative in high-flow years. In years that follow a very dry year in which Hungry Horse
5384 Reservoir water levels are well below the end of September elevations, minor reductions in
5385 TDG would be observed due to the reduced spill associated with lower reservoir water levels.
5386 Any spill operations conducted at Libby Dam would continue to cause elevated TDG
5387 downstream. Libby Dam is not expected to spill frequently under the No Action Alternative, so
5388 downstream TDG saturations are anticipated to typically remain less than 110 percent.

5389 Albeni Falls Dam spill is highly dependent on runoff volumes and, historically, Albeni Falls Dam
5390 has spilled most years. Under the No Action Alternative, these spillway operations are expected
5391 to continue in a manner similar to that described in the Affected Environment (Section 3.4.2).

5392 **Other Physical, Chemical, and Biological Processes**

5393 Under the No Action Alternative, nutrients or pollution would remain relatively low in Hungry
5394 Horse Reservoir. If coal production in the Kootenai River watershed above Libby Dam continues
5395 to increase, as it has over the past 20 years, this increase will lead to greater selenium and
5396 nitrate loadings into Lake Kootenai and the Kootenai River downstream of Libby Dam. Though
5397 separate from the operation of Libby Dam, the continued increase in nitrate loadings to Lake
5398 Kootenai could make the lake susceptible to increased algae blooms including potential
5399 nuisance species under the No Action Alternative.

5400 Current water quality conditions of Lake Pend Oreille and the Pend Oreille River are expected to
5401 continue under the No Action Alternative. If nutrients continue to increase in the nearshore
5402 areas, it is likely that nuisance aquatic growth would further impair beneficial uses in the future.

5403 **Sediment Quality**

5404 Similar to water quality, under the No Action Alternative, sediment-related processes and
5405 projects would continue to occur much as they do now as described in the Affected
5406 Environment (Section 3.4.2).

5407 Sediment accumulation behind the dams in Region A would continue under the No Action
5408 Alternative. Sediment that has accumulated behind the dams would remain a source of
5409 contamination to benthic and aquatic organisms in Libby Reservoir due to upstream mining
5410 activities. No known pollutants exist in Hungry Horse Reservoir or directly downstream of the
5411 dam.

5412 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

5413 **Water Quality**

5414 **Water Temperature**

5415 Lake Roosevelt at Grand Coulee has relatively short water retention times (i.e., the water does
5416 not stay in the reservoir for long) due to the large amount of flow through the reservoir. This
5417 short retention time results in water temperatures being fairly uniform across reservoir depths
5418 and at the dam’s penstock intake depths. Because of the nearly uniform water temperature in
5419 the reservoir, there is not a cold water layer from which to draw from during the summer. This
5420 results in Grand Coulee Dam releasing the coolest water possible in the summer months, based
5421 on constraints for generation reliability, voltage stability, and TDG standards. Lake Roosevelt
5422 does, however, exhibit the typical water temperature lag that is commonly seen in impounded
5423 waterbodies. The reservoir tends to be cooler in the spring and warmer in the fall as compared
5424 to undammed rivers. This pattern would continue in the future under the No Action Alternative.

5425 Chief Joseph Dam is a run-of-river project located downstream of Grand Coulee Dam. Little to
5426 no thermal stratification (i.e., different water temperature layers) occurs in Rufus Woods Lake,
5427 and water temperatures released from Grand Coulee Dam are passed downstream with little
5428 change due to the high flows and short retention time in the reservoir. Under the No Action
5429 Alternative, these conditions are expected to continue.

5430 ***Total Dissolved Gas***

5431 TDG often does not meet state water quality standards at the international border, or
5432 downstream of Grand Coulee or Chief Joseph Dams, during high-flow years when a spill occurs.
5433 TDG produced by the operation of Grand Coulee and Chief Joseph Dams is expected to remain
5434 unchanged and reflect conditions as described in the Affected Environment (Section 3.4.2). Spill
5435 would still be necessary when total flows exceed powerhouse capacity or for hydropower (lack
5436 of market) reasons. The Chief Joseph spillway would still be equipped with flow deflectors to
5437 reduce TDG in the Columbia River. Spill operations at Chief Joseph Dam that are used to
5438 manage TDG saturations in the Columbia River are not expected to change under the No Action
5439 Alternative.

5440 ***Other Physical, Chemical, and Biological Processes***

5441 Lake Roosevelt’s in-reservoir processes would continue under the No Action Alternative (see
5442 Appendix D). The rate of bioaccumulation of contaminants within the reservoir is anticipated to
5443 remain relatively unchanged from what is currently observed.

5444 In recent years, there has been an increase in harmful algae blooms in Rufus Woods Lake that
5445 are not attributed to the aquaculture facilities. These blooms are a fairly recent water quality
5446 issue, which remain unexplained, but are expected to continue in the future under the No
5447 Action Alternative.

5448 **Sediment Quality**

5449 Similar to water quality, under the No Action Alternative, sediment-related processes and
5450 projects would continue to occur much as they do now, as described in the Affected
5451 Environment (Section 3.4.2).

5452 Sediment accumulation behind the dams in Region B would continue under the No Action
5453 Alternative. Sediment that has accumulated behind the dams would remain a source of
5454 contamination to benthic and aquatic organisms. Some pesticides or other compounds may
5455 slowly degrade over time; however, metals and the bulk of organic pollutants would remain in
5456 the accumulated sediment. Contaminants of concern in the sediment would continue to include
5457 metals, mercury, PCBs, dioxins, pesticides, and other organic compounds (mostly from human
5458 sources).

5459 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
5460 **HARBOR DAMS**

5461 **Water Quality**

5462 ***Water Temperature***

5463 Dworshak is a deep, cold water reservoir that exhibits strong thermal stratification regardless of
5464 the quantity of water entering the reservoir (i.e., runoff year). As such, under the No Action
5465 Alternative, sufficient cold water that is less than 52°F is expected to continue to be available to
5466 moderate lower Snake River temperatures during the summer (see Appendix D).

5467 Water temperatures at the lower Snake River projects as described in Section 3.4.2 would
5468 continue under the No Action Alternative. As noted earlier, historical temperatures in the
5469 lower Snake River Basin prior to the construction of the lower Snake River dams and the Hells
5470 Canyon Complex show that temperatures in the free-flowing lower Snake River often exceeded
5471 68°F (20°C) in July and August and occasionally exceeded 25°C. The effects of the Dworshak
5472 Dam summer cool water releases are expected to continue to influence water temperatures in
5473 the lower Snake River. The most noticeable effect of the cool water releases would be noted at
5474 Lower Granite Reservoir where water temperature stratification is expected to occur during the
5475 summer and tailwater temperatures would usually be held at less than 68°F during the summer
5476 (see Appendix D). The cooling effect from the Dworshak water releases would diminish at each
5477 successive downstream reservoir after Lower Granite and the frequency of water temperatures
5478 exceeding water temperature standards would increase downstream of Lower Granite Dam.
5479 Winter water temperatures would continue to be in the low 30°F range, with some surface
5480 icing during colder winters.

5481 **Total Dissolved Gas**

5482 Under the No Action Alternative, TDG is anticipated to be less than 110 percent the majority of
5483 the time below Dworshak Dam, although short-term exceptions would likely occur when flows
5484 exceed powerhouse capacity.

5485 The four lower Snake River dams are run-of-river projects, and TDG production is highly related
5486 to runoff volume. Excursions above the WQSS in place in 2016 (115 percent forebay and 120
5487 percent tailwater) are expected to continue during the fish spill season (April through August)
5488 at a frequency of that observed in recent years. Additionally, because expressed TDG
5489 saturation is temperature dependent, elevated TDG saturation would also be expected to occur
5490 during low-flow conditions when the air temperatures are high.

5491 **Other Physical, Chemical, and Biological Processes**

5492 Dworshak Reservoir nutrient fertilization occurs annually and is expected to continue under the
5493 No Action Alternative. As the program continues, additional data should help identify whether
5494 the observed shifts in water quality are due to the fertilization program or changes related to
5495 the inflows, natural aging of the lake, or other unidentified causes.

5496 The lower Snake River contains a variety of human-sourced compounds, including metals and
5497 organic compounds. Continued pollutant and nutrient loading is expected due to farming
5498 activities, industry, and urban and agricultural runoff. In addition, models suggest that the
5499 current moderate to high levels of nutrients (i.e., mesotrophic to eutrophic conditions) in the
5500 lower Snake River reservoirs is unlikely to change under the No Action Alternative. Thus, it is
5501 expected that the current water quality impairments would continue under the No Action
5502 Alternative.

5503 **Sediment Quality**

5504 Sediment-related processes and projects would continue to occur in a similar manner as
5505 described above for Region B. Additionally, sediment management activities in the lower Snake
5506 River (as described in the Programmatic Sediment Management Plan (Corps 2014) and other
5507 documents) would continue as currently planned under the No Action Alternative. Areas that
5508 historically have required dredging (lock chamber approaches, harbor and port berthing areas
5509 and entrances) would still experience shoaling (buildup of sediment in shallow areas). The
5510 Federal Navigation Channel (FNC) and private dockface/berthing area dredging to maintain
5511 navigation would still occur.

5512 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

5513 **Water Quality**

5514 ***Water Temperature***

5515 The four lower Columbia River reservoirs (McNary, John Day, The Dalles, and Bonneville) would
5516 continue to show weak to no water temperature stratification during the summer months. This
5517 would largely be due to the short time water is in the reservoirs and water mixing⁶ that occurs
5518 in the reservoirs. Exceedances of water temperature standards in Region D occur during the
5519 summer under a range of river and meteorological conditions and would be expected to
5520 continue to occur under the No Action Alternative (see Appendix D).

5521 ***Total Dissolved Gas***

5522 The lower Columbia River dams in Region D are operated as run-of-river projects (albeit John
5523 Day has a small amount of storage), and TDG production is highly related to runoff volume. A
5524 similar frequency of TDG exceedances above the WQS in place in 2016 (115 percent forebay
5525 and 120 percent tailwater) are expected to continue to occur during the juvenile fish passage
5526 spill season under the No Action Alternative. Additionally, because TDG saturation is
5527 temperature dependent, elevated TDG would be expected to occur during low-flow conditions
5528 when the air temperatures are high.

5529 ***Other Physical, Chemical, and Biological Processes***

5530 The lower Columbia River contains a variety of human-sourced compounds, including metals
5531 and organic compounds. Continued pollutant and nutrient loading is expected due to farming
5532 activities, industry, and urban and agricultural runoff. In addition, data suggests that the
5533 moderate to high levels of nutrients (i.e., mesotrophic to eutrophic conditions) in these
5534 reservoirs is unlikely to change under the No Action Alternative. Thus, it is expected that the
5535 current water quality impairments in the lower Columbia River would continue under the No
5536 Action Alternative.

5537 **Sediment Quality**

5538 Sediment-related processes and projects would continue to occur in a similar manner as that
5539 described above for Region C.

5540 **SUMMARY OF EFFECTS**

5541 Water and sediment quality under the No Action Alternative would be expected to continue in
5542 a similar manner as that described in Section 3.4.2, *Water Quality Affected Environment*.

⁶ Water mixing may occur from wind, water flows, or sinking cold water (i.e., convective mixing).

5543 Although the effects of the No Action Alternative differ across the various projects in terms of
5544 water and sediment quality, they can generally be categorized as follows.

5545 In Region A, TDG does not always meet the state of Montana's standard of 110 percent below
5546 Hungry Horse Dam during high-flow years when flow exceeds powerhouse capacity and water
5547 is released through the dam outlets known to produce TDG. This is expected to continue under
5548 the No Action Alternative in high-flow years. Any spill operations conducted at Libby Dam
5549 would continue to cause elevated TDG downstream. Increases in nitrate loadings to Lake
5550 Kooncanusa and the Kootenai River could lead to increased algal blooms and associated nuisance
5551 species. Contaminated sediment accumulation behind Libby Dam in Region A would continue
5552 under the No Action Alternative.

5553 In Region B, water temperature lags associated with Lake Roosevelt would continue, and water
5554 temperatures released from Grand Coulee Dam would be passed downstream and through
5555 Lake Rufus Woods with little change due to high flows and short retention times. TDG produced
5556 by the operation of Grand Coulee and Chief Joseph Dams is expected to remain unchanged.
5557 Algae blooms in Rufus Woods Lake would be expected to continue.

5558 In Region C, thermal stratification at Dworshak reservoir and the release of cold water to
5559 moderate lower Snake River temperatures would be expected to continue. TDG would be
5560 anticipated to be less than 110 percent the majority of the time below Dworshak Dam, while a
5561 similar frequency of TDG exceedances above WQS in place in 2016 (115 percent forebay and
5562 120 percent tailwater) are expected to continue in the lower Snake River. Continued pollutant
5563 and nutrient loading is expected due to farming, industry, and urban and agricultural runoff in
5564 the lower Snake River.

5565 In Region D, little to no water temperature stratification would occur during the summer
5566 months, and exceedances of water temperature standards would continue under a range of
5567 river and meteorological conditions. Similar frequencies of TDG exceedances above current
5568 standards are expected to continue during the juvenile fish spill season (April through August).
5569 Continued pollutant and nutrient loading is expected due to farming, industry, and urban and
5570 agricultural runoff.

5571 **3.4.3.4 Multiple Objective Alternative 1**

5572 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

5573 **Water Quality**

5574 **Water Temperature**

5575 In general, the water temperature response at the Libby and Hungry Horse Dams are expected
5576 to be similar to the No Action Alternative. However, slight changes in water temperatures
5577 downstream of Libby Dam could occur due to the *December Libby Target Elevation* and
5578 *Modified Draft at Libby* measures. With these measures, water temperatures downstream of

5579 Libby Dam could be warmer in the winter and colder in the early spring as compared to the No
5580 Action Alternative.

5581 There are no changes to operations expected at Albeni Falls Dam under MO1, so the
5582 temperature conditions in Lake Pend Oreille and the Pend Oreille River are expected to remain
5583 unchanged under MO1 and reflect conditions as described in the No Action Alternative.

5584 **Total Dissolved Gas**

5585 In general, MO1 would have little to no impact on TDG conditions below Libby, Hungry Horse,
5586 and Albeni Falls Dams as compared to the No Action Alternative.

5587 TDG below Hungry Horse Dam under MO1 is expected to be relatively similar to the No Action
5588 Alternative in most years. The winter and spring operations at Hungry Horse Dam are not
5589 specifically targeted by any of the MO1 measures, but due to changes in reservoir elevations at
5590 the end of September from *the Hungry Horse Additional Water Supply* measure and the *Sliding*
5591 *Scale at Libby and Hungry Horse* measure, winter and spring reservoir elevations and outflows
5592 would be impacted. In the years that follow a very dry year, in which Hungry Horse Reservoir
5593 water levels are well below the summer flow augmentation elevation objectives at the end of
5594 September, minor reductions in TDG would be observed due to the reduced outflow and spill
5595 the following spring associated with lower reservoir water levels.

5596 Libby Dam is operated to minimize spill. Under MO1, Libby Dam's draft and refill operations
5597 would be modified, resulting in a minor increase in spill compared to the No Action Alternative.
5598 For the 80-year period from 1928 to 2008, model results predict 6 years with spill under MO1
5599 compared to 2 years when spill would occur for the No Action Alternative. In those years
5600 identified as having spill at Libby Dam, the model predicts 35 days with TDG exceeding 110
5601 percent for MO1 versus only 8 days with TDG exceedances under the No Action Alternative.
5602 Regardless, Libby Dam is not expected to spill frequently under MO1, so downstream TDG
5603 saturations should remain less than 110 percent the majority of time.

5604 Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills
5605 most years. Because there is no change in Albeni Falls Dam operations between MO1 and the
5606 No Action Alternative, spillway operations and TDG conditions under MO1 are expected to
5607 remain unchanged.

5608 **Other Physical, Chemical, and Biological Processes**

5609 Negligible impacts to the physical, chemical, or biological processes at Hungry Horse Reservoir
5610 and the South Fork Flathead River downstream of the dam, are expected as compared to the
5611 No Action Alternative. Although the operational measures *Hungry Horse Additional Water*
5612 *Supply* and *the Sliding Scale at Libby and Hungry Horse* could result in deeper reservoir
5613 drawdowns, stratification that would influence nutrient levels in Hungry Horse Reservoir are
5614 not expected to change. There may be some reductions to primary and secondary productivity

5615 in the reservoir due to changes in outflows and storage, but effects would be negligible as
5616 compared to the No Action Alternative.

5617 MO1 would result in changes to water levels in Lake Koocanusa that may impact physical,
5618 chemical, and biological water quality parameters when compared to existing conditions and
5619 the No Action Alternative. Parameters of concern in Lake Koocanusa that may be altered by
5620 MO1 include changes to nutrients (such as phosphorus and nitrogen), selenium, and
5621 phytoplankton. Although unrelated specifically to MO1, coal production in the Kootenai River
5622 watershed above Libby Dam may continue to increase, as it has over the past 20 years. This
5623 increase, together with changes in reservoir elevations and the amount of time water spends in
5624 the reservoir under MO1, may lead to greater quantities of selenium and nitrate in Lake
5625 Koocanusa and the Kootenai River downstream of Libby Dam. The shorter residence time
5626 (amount of time that water stays in the reservoir) may also allow phosphorus to move farther
5627 down reservoir before settling out or transforming. This increase in nutrients available in the
5628 reservoir could make the lake more susceptible to increased phytoplankton blooms including
5629 potentially toxic species under MO1.

5630 Water quality conditions of Lake Pend Oreille and the Pend Oreille River described for the
5631 affected environment and the No Action Alternative are expected to continue under MO1.

5632 **Sediment Quality**

5633 Operational changes at Libby and Hungry Horse Dams under MO1 are not expected to affect
5634 sediment movement downstream in the Kootenai and Flathead Rivers, respectively. MO1
5635 would not impact Albeni Falls Dam operations and would not affect sediment sources or
5636 movement.

5637 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

5638 **Water Quality**

5639 ***Water Temperature***

5640 The water temperature in Lake Roosevelt would not likely be affected by upstream flow
5641 changes or by the five operational measures (*Update System FRM Calculation, Planned Draft*
5642 *Rate at Grand Coulee, Grand Coulee Maintenance Operations, Winter System FRM Space, and*
5643 *Lake Roosevelt Additional Water Supply*) called for under MO1.

5644 For Columbia River temperatures downstream of Grand Coulee Dam, model results suggest
5645 there would be a negligible change in water temperatures, on average. The number of days
5646 that water temperatures would exceed Washington State WQSs would be reduced by 1 day per
5647 year, on average. Changes to Grand Coulee Dam outflows would be carried through Rufus
5648 Woods Lake, Chief Joseph Dam, and downstream. These flow changes are relatively small and
5649 would result in a negligible change in Rufus Woods Lake elevations when compared to the No

5650 Action Alternative. As such, Chief Joseph Dam tailwater temperatures under MO1 would be
5651 similar to the No Action Alternative.

5652 **Total Dissolved Gas**

5653 Downstream of Grand Coulee Dam, major reductions in TDG, as compared to the No Action
5654 Alternative, would occur due to the MO1 measures that call on more operational flexibility for
5655 FRM (*Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Grand Coulee*
5656 *Maintenance Operations, and Winter System FRM Space*) and the water supply measure (*Lake*
5657 *Roosevelt Additional Water Supply*). The major maintenance measure (*Grand Coulee*
5658 *Maintenance Operations*), which is expected to temporarily reduce the powerhouse capacity of
5659 Grand Coulee Dam and increase the magnitude of spill and TDG in some situations, was
5660 balanced by improvements to TDG associated with the other Grand Coulee measures. TDG
5661 effects anticipated at Grand Coulee would be carried downstream of Chief Joseph Dam and
5662 Reservoir. During high flow years, the spillway deflectors at Chief Joseph Dam would provide
5663 reductions (degassing) of elevated TDG levels generated from upstream Canadian dam and
5664 Grand Coulee Dam operations. TDG effects downstream of Chief Joseph Dam under MO1 are
5665 negligible.

5666 **Other Physical, Chemical, and Biological Processes**

5667 Qualitative analysis suggests that, when compared to the No Action Alternative, MO1 could
5668 have minor effects to physical, chemical, and biological processes in Lake Roosevelt. The slower
5669 drawdown from the *Planned Draft Rate at Grand Coulee* measure could provide minor
5670 reductions in local landslides and associated high turbidity, and thereby improve water quality.
5671 However, water level fluctuations in the reservoir (due to the *Update System FRM Calculation,*
5672 *Planned Draft Rate at Grand Coulee, and Winter System FRM Space* measures) may increase
5673 methylmercury in the waterbody. The MO1 measures would not change the number of times
5674 portions of the reservoir banks and margins are covered with water (inundated), but the MO1
5675 measures would result in earlier and longer exposure of sediments. This longer sediment
5676 exposure may increase the amount of mercury that is converted to methylmercury upon
5677 rewatering the area. Methylmercury is the more toxic form of mercury that bioaccumulates in
5678 fish tissue. Minor changes to water retention times passing through the reservoir from
5679 February through July are not expected to result in changes to algae blooms, pH, or dissolved
5680 oxygen conditions. No additional physical, chemical, or biological water quality effects are
5681 expected to occur in the Columbia River immediately below Grand Coulee Dam.

5682 Chief Joseph Dam and Rufus Woods Lake elevations and flows under MO1 are predicted to be
5683 similar to the No Action Alternative. As such, the water quality of Rufus Woods Lake under MO1
5684 would be similar to the No Action Alternative. The harmful algae blooms described for the
5685 affected environment and the No Action Alternative would be expected to continue in the
5686 future under MO1.

5687 **Sediment Quality**

5688 Minor increases in the mobilization of sediment and shoreline erosion is expected within Lake
5689 Roosevelt due to changes in elevations under MO1 from the *Update System FRM Calculation*,
5690 *Planned Draft Rate at Grand Coulee*, *Grand Coulee Maintenance Operations*, *Winter System*
5691 *FRM Space*, and *Lake Roosevelt Additional Water Supply* measures. However, it is not
5692 anticipated that additional sediment would pass the dam; expected effects would occur within
5693 the reservoir. In comparison to the No Action Alternative, MO1 flow changes at Chief Joseph
5694 Dam would be minor, and no effects to sediment sources or movement would be expected.

5695 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
5696 **HARBOR DAMS**

5697 **Water Quality**

5698 ***Water Temperature***

5699 Under MO1, Dworshak Reservoir would continue to thermally stratify during the summer, and
5700 outflow water temperatures would remain less than the Idaho State water quality standard of
5701 55.4°F. Water temperatures in the lower Snake River would increase during August, due to the
5702 *Modified Dworshak Summer Draft* measure. Under MO1, cool water would be discharged into
5703 the lower Snake River from June 21 to August 1. During August, total Dworshak outflows would
5704 be reduced to preserve cold water for release again in September. This modified Dworshak
5705 operation would result in a moderate increase in water temperatures in the lower Snake River,
5706 on average. It is not anticipated that fish ladder water temperature improvements at Lower
5707 Monumental and Ice Harbor Dams (*Lower Snake Ladder Pumps*) would have any meaningful
5708 impact to downstream river water temperatures. These structural changes would be
5709 anticipated to effect fish ladder conditions only.

5710 ***Total Dissolved Gas***

5711 Implementing MO1 would lead to negligible changes to TDG saturation below Dworshak Dam
5712 for most flow and temperature conditions. There are two measures within MO1 that would
5713 modify juvenile fish passage spill operations in the lower Snake River; the *Block Spill Test (Base*
5714 *+ 120/115%) Measure* and the *Summer Spill Stop Trigger*. The *Block Spill Test* calls for a spill
5715 test to evaluate the latent mortality hypothesis; spill operations switch between performance
5716 (base) spill and a test spill operation within a given season. The *Summer Spill Stop Trigger* calls
5717 for the early end to summer juvenile fish passage spill operations at the lower Snake River
5718 projects. Ending dates vary from August 6 to 21, depending on the dam. Due to the within-
5719 season switch between operations at the dams, in conjunction with an assumed higher amount
5720 of lack of load/lack of market spill, model results showed a negligible difference in TDG levels
5721 under MO1, even with these operational measures, as compared to the No Action Alternative.

5722 **Other Physical, Chemical, and Biological Processes**

5723 Having water stay longer in Dworshak Reservoir during August under the *Modified Dworshak*
5724 *Summer Draft Measure* could lead to additional blue-green algae growth. However, liquid
5725 fertilizer is currently added (and would be expected to continue) to the reservoir to manage the
5726 nitrogen to phosphorus ratio (nutrient balance). The continuation of the nutrient balancing
5727 would be expected to prevent the formation of hazardous algal blooms as a result in the
5728 change to Dworshak operation under MO1.

5729 Increased water temperatures (as described above), along with higher concentrations of
5730 soluble nutrients and a longer time water stays in reservoirs in the lower Snake River during
5731 August, would likely foster additional growth of cyanobacteria (blue-green algae) in swim areas
5732 and boat basins.

5733 **Sediment Quality**

5734 MO1 includes structural changes aimed at improving juvenile fish passage in Region C; these
5735 proposed measures would not affect sediment sources or movement because they do not
5736 change the overall flow range experienced in the river, and the measures would not result in
5737 disturbance of the sediment held deep within the reservoir. The proposed operational changes
5738 generally have a goal of improving flexibility in operation and of improving in-stream (flow and
5739 temperature) conditions for fish; changing the timing of operational flows or the temperature
5740 characteristics would not affect sediment sources. MO1 is not expected to affect land use
5741 throughout the basin, including upland recreation, FRM, agricultural, timber, or mining
5742 activities, and is not expected to change population growth patterns in the area of any of the
5743 affected reservoirs. Overall, MO1 is not expected to affect sediment movement within Region
5744 C.

5745 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

5746 **Water Quality**

5747 **Water Temperature**

5748 Under MO1 and as with the No Action Alternative, the four lower Columbia River reservoirs
5749 (McNary, John Day, The Dalles, and Bonneville) would continue to show weak to no water
5750 temperature stratification during the summer months largely due to the time water is in the
5751 reservoirs and water mixing that occurs in the reservoirs. Maximum tailwater temperatures and
5752 the frequency of water temperature standard exceedances would be similar for MO1 and the
5753 No Action Alternative over a range of river and meteorological conditions; negligible effects are
5754 anticipated.

5755 **Total Dissolved Gas**

5756 Similar to that described for the lower Snake River projects in Region C, the measures within
5757 MO1 that modify spill would have a negligible effect on TDG levels under MO1 as compared to
5758 the No Action Alternative for the lower Columbia River projects.

5759 **Other Physical, Chemical, and Biological Processes**

5760 For Region D, MO1 would have no change on the physical, chemical, or biological water quality
5761 impairments.

5762 **Sediment Quality**

5763 Overall, sediment quality within Region D would change little from the No Action Alternative as
5764 the structural measures, operational changes, nor would land use under MO1 impact sediment
5765 sources or movement.

5766 **SUMMARY OF EFFECTS**

5767 Although the effects of MO1 differ across the various projects in terms of water and sediment
5768 quality, they can generally be categorized as follows:

5769 In Region A, MO1 is expected to have negligible to minor effects to water temperatures and
5770 TDG conditions at the projects when compared to what would occur under the No Action
5771 Alternative. There would be a minor increase in spill and associated TDG levels at Libby Dam
5772 due to the project's draft and refill operations. Minimal changes to the physical, chemical, or
5773 biological processes in most locations in Region A would occur. Elevated concentrations of
5774 selenium and nitrate-nitrogen in Lake Kocanusa and the Kootenai River downstream may
5775 occur due to the increased reservoir elevations that may concentrate these contaminants.
5776 Lastly, MO1 would not impact turbidity or sediment concentrations in the region. Overall, these
5777 effects are expected to be negligible to minor.

5778 In Region B, MO1 is expected to have negligible effects on water temperatures when compared
5779 to the No Action Alternative. Major reductions in TDG would occur downstream of Grand
5780 Coulee due to the *Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Grand*
5781 *Coulee Maintenance Operations, and Winter System FRM Space and Lake Roosevelt Additional*
5782 *Water Supply* measures. Slight increases in mercury solubility in Lake Roosevelt may occur, but
5783 there would be little to no additional changes compared to the No Action Alternative to the
5784 physical, chemical, and biological processes elsewhere. The minor additional mobilization of
5785 sediment is expected to occur in Lake Roosevelt, but no additional changes to sediment quality
5786 are anticipated. Overall, these effects are expected to be negligible to minor. Negligible impacts
5787 are expected in Lake Rufus Woods or downstream of Chief Joseph Dam.

5788 In Region C, MO1 is expected to increase the number of days that water temperatures would
5789 exceed Washington State water quality standards in the lower Snake River due to the *Modified*
5790 *Dworshak Summer Draft* measure. Major impacts would be expected in the Lower Granite

5791 tailwater with an additional 18 days of exceedances per year on average, as compared to the
5792 No Action Alternative. Negligible impacts would be expected in the Ice Harbor tailwater with an
5793 additional 5 days of exceedances per year, on average as compared to the No Action
5794 Alternative. Increased water temperatures may result in additional growth of blue-green algae
5795 in the region. Little to no changes in TDG concentrations and sediment movement would occur.
5796 Overall, the effects to water quality would be moderate for water temperature and negligible
5797 to minor for TDG and other water quality parameters.

5798 In Region D, MO1 is expected to result in little to no change to water temperatures, TDG,
5799 sediment quality, or other water quality parameters when compared to the No Action
5800 Alternative. These effects are expected to be negligible.

5801 For further details, please refer to the Water Quality Technical Appendix D.

5802 **3.4.3.5 Multiple Objective Alternative 2**

5803 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

5804 **Water Quality**

5805 **Water Temperature**

5806 Under MO2, the SWSs at Hungry Horse and Libby Dams would continue to be operational.
5807 However, thermal stratification must be present in the forebay for the SWSs to achieve
5808 temperatures as close as possible to downstream water temperature objectives, critical for
5809 resident fish species. The onset of thermal stratification is difficult to predict and can vary from
5810 year to year due to reasons such as inflow volumes, inflow temperatures, reservoir drawdown
5811 elevation, discharge volumes, and weather conditions. Historical temperature data suggests
5812 that holding the reservoir water levels higher in the winter results in colder reservoir water
5813 temperatures and difficulty for the SWSs to achieve desired water temperatures the following
5814 spring/early summer.

5815 When Libby and Hungry Horse Reservoirs are drafted deeper, the reservoir volume is less,
5816 thereby allowing for greater warming in the spring and summer from warmer inflows and
5817 warming air temperatures. Under MO2, lower reservoir elevations are anticipated due to the
5818 *Slightly Deeper Draft for Hydropower* measure and would likely be substantial enough to result
5819 in a change in Lake Kootenai and Hungry Horse Reservoir water temperatures and thermal
5820 stratification as compared to the No Action Alternative. These lower reservoir elevations are
5821 likely to result in slightly warmer reservoir temperatures and earlier thermal stratification
5822 during the spring and summer resulting in a greater ability for the SWSs to achieve downstream
5823 temperatures when compared to the No Action Alternative.

5824 Downstream of Libby Dam, higher November and December outflows may delay the natural
5825 cooling of the Kootenai River downstream of the dam. The higher outflows in November and
5826 December are caused by the combination of the *Slightly Deeper Draft for Hydropower* measure

5827 with the *December Libby Target Elevation* measure. When combined, these measures result in
5828 a reservoir elevation of 2,400 feet NGVD29. This deeper draft to 2,400 feet NGVD29 at the end
5829 of December, and the subsequent reservoir levels through the winter, however, may allow for
5830 the reservoir to warm earlier in the spring, providing for earlier (and beneficial) warming to
5831 water temperatures downstream of the dam.

5832 Operations specific to Albeni Falls would change little under MO2 as compared to the No Action
5833 Alternative. However, upstream flow changes, such as those called for under MO2 at Hungry
5834 Horse Dam, would result in flow changes in the Flathead River that would be evident
5835 downstream through the Pend Oreille Basin. These operational changes would result in minor
5836 temperature changes downstream of Albeni Falls Dam, ranging from a decrease of about 0.9
5837 degree Fahrenheit to an increase of about 2.7 degrees Fahrenheit, with the greatest
5838 differences occurring during the winter months (January/February).

5839 ***Total Dissolved Gas***

5840 MO2 would modify Libby Dam's drawdown and refill operations, resulting in a small increase in
5841 spill compared to the No Action Alternative. For the 80-year period from 1928 to 2008, model
5842 results predict that spill would occur in 6 years under MO2 versus only occurring in 2 years for
5843 the No Action Alternative. In those spill years, MO2 would have 27 days with TDG exceeding
5844 110 percent while only 8 days would exceed the TDG standards under the No Action
5845 Alternative. Regardless, Libby Dam is not expected to spill frequently under MO2, so
5846 downstream TDG saturations should remain less than 110 percent the majority of time.

5847 The *Slightly Deeper Draft for Hydropower* measure allows for greater operational flexibility and
5848 would result in deeper winter drawdowns at Hungry Horse Reservoir. This, in turn, would
5849 reduce spring outflows and spill in some cases. As a result, the number of days that TDG below
5850 the dam would be greater than 110 percent under MO2 is expected to be lower than the No
5851 Action Alternative in most years.

5852 Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills
5853 most years. Because there are little changes in Albeni Falls Dam operations between MO2 and
5854 the No Action Alternative, spillway operations under MO2 are expected to remain unchanged.

5855 ***Other Physical, Chemical, and Biological Processes***

5856 The modified operations under MO2 would result in changes in the drafting depth, water
5857 elevations, and retention times of Lake Koocanusa and Hungry Horse Reservoir. This could lead
5858 to higher flushing rates and reductions in primary and secondary productivity in the reservoirs.
5859 Water quality chemical and biological parameters of concern in Lake Koocanusa that may be
5860 impacted by MO2's shorter residence times include nutrients such as phosphorus and nitrogen,
5861 suspended sediments, metals such as selenium, and phytoplankton.

5862 Water quality conditions of Lake Pend Oreille and the Pend Oreille River described for the
5863 affected environment and the No Action Alternative are expected to continue under MO2.

5864 **Sediment Quality**

5865 MO2 includes operational changes that would result in water level changes at some reservoirs.
5866 These changes would have little overall effect on sediment within Region A. Additional
5867 shoreline erosion could occur at some reservoirs that have large water elevation fluctuations;
5868 however, the sediment that erodes would be trapped within the reservoirs and would not
5869 move downstream. MO2 is not expected to affect land use throughout the basin, including
5870 upland recreation, FRM, agricultural, timber, or mining activities, and it is not expected to
5871 change population growth patterns in the area of any of the affected reservoir. The
5872 contaminants of concern in the sediment are expected to remain the same. Overall, MO2 is
5873 expected to have little impact on sediment conditions within Region A in comparison to the No
5874 Action Alternative.

5875 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

5876 **Water Quality**

5877 ***Water Temperature***

5878 The Grand Coulee Dam area, comprised of Lake Roosevelt above the dam and the Columbia
5879 River below, are affected by five operational measures (*Slightly Deeper Draft for Hydropower,*
5880 *Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Grand Coulee*
5881 *Maintenance Operations, Winter System FRM Space*). These measures would result in an
5882 earlier and sometimes deeper drawdown of Lake Roosevelt and changes to inflow due to
5883 changes in operations at the upstream projects. Many of the measures would be implemented
5884 in the winter when the reservoir is nearly the same temperature (i.e., isothermal) so
5885 downstream temperatures during the winter would not be affected. The carry-over effects
5886 from these measures, however, may reduce the cold water mass that tends to cool inflowing
5887 water from upstream sources in the spring and early summer. This could result in minor
5888 warming in the spring and early summer, especially in LF/HT years (see Section 3.4.3.1 for
5889 definitions). Overall, MO2 is expected to have negligible effects on water temperature.

5890 Flow changes observed at Grand Coulee Dam would move downstream through Rufus Woods
5891 Lake and Chief Joseph Dam. Water temperatures under MO2 at Chief Joseph Dam tailwater
5892 would be similar to, or slightly cooler than, the No Action Alternative with the majority of
5893 temperature differences in the ± 1 to 2 degrees Fahrenheit range. However, for the AF/AT and
5894 LF/HT scenarios (see Section 3.4.3.1 for definitions), spring and early summer water
5895 temperatures would be 1 to 2 degrees Fahrenheit warmer under MO2. Tailwater temperatures
5896 under MO2 are predicted to exceed the Washington State water quality standard of 63.5°F, as
5897 measured by the 7-day average of the daily maximum temperature throughout the months of
5898 August and September; these exceedances occur under No Action as well. In general, MO2
5899 water temperature changes at Chief Joseph Dam would be negligible.

5900 **Total Dissolved Gas**

5901 The *Grand Coulee Maintenance Operation* measure, in isolation, could result in substantial
5902 increases in spill and TDG, and in some cases, produce TDG in excess of 130 percent; however,
5903 this effect is largely offset in the spring and early summer by other measures, such as the
5904 *Slightly Deeper Draft for Hydropower* measure that would result in lower reservoir elevations in
5905 late winter/early spring. Compared to the No Action Alternative, MO2 results in a reduction in
5906 TDG, particularly in May and June, in the Columbia River below Grand Coulee Dam. MO2 model
5907 results indicate that TDG would decrease, particularly in average flow years, from May 1 to mid-
5908 June by 5 percent to 10 percent. This effect is considered a major reduction using the logic
5909 presented in Section 3.4.3.2.

5910 At Chief Joseph Dam, forebay and tailwater TDG saturations are predicted to be similar to or
5911 slightly less than the No Action Alternative under MO2 for a wide range of flow and air
5912 temperature conditions. Overall TDG impacts under MO2, as compared to the No Action
5913 Alternative, are negligible.

5914 **Other Physical, Chemical, and Biological Processes**

5915 At Grand Coulee, operational measures including the *Winter System FRM Space, Deeper Draft*
5916 *for Hydropower*, and the influence from upstream projects would result in an increase in
5917 outflows from November to January. In January through March, the *Planned Draft Rate at*
5918 *Grand Coulee* would likely cause Lake Roosevelt to be drafted more slowly in some cases,
5919 potentially reducing local landslides (which can cause turbidity) and thereby improve water
5920 quality. However, earlier and deeper reservoir drawdowns at Grand Coulee could result in the
5921 longer duration and exposure of reservoir shoreline sediment and increase the potential for
5922 mercury solubility in the reservoir water (although the measures would not change the number
5923 of occurrences of repeated inundation and exposure of sediment in comparison to the No
5924 Action Alternative). Increased exposure has the potential to increase mercury methylation
5925 rates, which could lead to greater buildup of mercury quantities in aquatic organisms (i.e.,
5926 bioaccumulation) (Willacker 2016), among other potential contributing factors. No notable
5927 effects are likely to occur in the Columbia River immediately below Grand Coulee Dam.

5928 Chief Joseph Dam and Rufus Woods Lake elevations and flows under MO2 are predicted to be
5929 similar to the No Action Alternative. As such, the water quality of Rufus Woods Lake under MO2
5930 would be similar to the No Action Alternative. The harmful algae blooms described for the
5931 affected environment and the No Action Alternative would be expected to continue in the
5932 future under MO2.

5933 **Sediment Quality**

5934 Similar to that described for Region A, MO2 includes operational changes that would result in
5935 water level changes at some reservoirs, but the changes would have little overall effect on
5936 sediment within Region B. Overall, MO2 is expected to have little impact on sediment
5937 conditions within Region B.

5938 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
5939 **HARBOR DAMS**

5940 **Water Quality**

5941 ***Water Temperature***

5942 Deeper drawdowns of Dworshak Reservoir from the *Slightly Deeper Draft for Hydropower*
5943 measure, ranging from 12 to 38 feet in the spring, could lead to slower warming of the surface
5944 waters because the smaller surface area would result in less warming by the sun in the early
5945 spring. Near-full pool would be reached by July, and thermal stratification for the remainder of
5946 the year would not change. Average outflow temperatures would be approximately 0.8 to
5947 1.6degrees Fahrenheit warmer in May, June, and July during AF/AT conditions (see Section
5948 3.4.3.1 for definitions). Mean monthly temperature changes for April through September for
5949 the other flow and weather conditions modeled would range from -0.5 to 0.6 degree
5950 Fahrenheit. However, maximum temperatures would remain less than 52°F throughout the
5951 year, and overall water temperature effects downstream of Dworshak Dam under MO2 would
5952 be negligible using the logic presented in Section 3.4.3.2.

5953 MO2 water temperatures in the lower Snake River would result in moderate to minor changes
5954 as modeled, compared to the No Action Alternative. Under MO2, ResSim modeling assumptions
5955 did not represent the intended operations and instead showed the reservoir would have a
5956 decreased refill probability, refilling to within 0.5 feet of the normal full reservoir elevation in
5957 about 48 percent of years. It is likely that in real-time operations, the refill probability for
5958 Dworshak Reservoir under MO2 would be higher than shown in modeled results, and more
5959 closely aligned to the No Action Alternative. Therefore, effects to water temperatures are
5960 considered negligible in Region C.

5961 ***Total Dissolved Gas***

5962 TDG saturation downstream of Dworshak Dam would remain below 110 percent for most of the
5963 year, with a few exceptions. Some increases in downstream TDG occurred in the modeling
5964 results during high-flow years due to the modeling assumption that increased outflow in the
5965 spring. The spring modeling assumption did not represent the desired operation as defined in
5966 the *Slightly Deeper Draft for Hydropower* measure. In actual operations, spill would be
5967 consistent with water quality criteria, and these impacts would be avoided, when possible,
5968 during implementation of this measure. Overall effects are anticipated to be negligible for TDG.

5969 The *Spill to Near 110 Percent TDG* measure limits juvenile fish passage spill at the lower Snake
5970 and Columbia dams to 110 percent TDG as measured in-river, including tailraces and
5971 downstream forebays except when higher minimum spill levels are required for powerhouse
5972 surface passage routes, for spillway weirs, and/or for adult attraction. Additionally, spill during
5973 high flow and flood events would not be restricted to a cap of 110 percent TDG, but rather set
5974 to levels necessary for safety. Lack-of-market spill would also continue, and would follow the
5975 spill priority list. TDG in the lower Snake River downstream of Lower Granite Dam would be

5976 greater than 110 percent from April through July during most flow and meteorological
5977 conditions due to lack-of-turbine spill and/or spill for lack-of-market. Maximum TDG values
5978 would still exceed 120 and 125 percent during May, June, and July. However, because spill for
5979 juvenile fish passage would no longer occur during August under MO2, there would be a minor
5980 decrease in the amount of time that TDG levels exceeded 110 percent in August. Overall
5981 impacts to TDG in the lower Snake River under MO2 would range from minor to negligible.

5982 ***Other Physical, Chemical, and Biological Processes***

5983 The lower water elevation of the Dworshak Reservoir from April through June would result in a
5984 smaller surface area and consequently slower warming of the surface by the sun. Additionally,
5985 shallower water depths at the upper end of the reservoir would lead to faster water travel
5986 times and delayed primary production.

5987 Water quality conditions, as described for the affected environment and the No Action
5988 Alternative, are expected to continue under MO2 for the lower Snake River.

5989 **Sediment Quality**

5990 Similar to that described for Region A, MO2 includes operational changes that would result in
5991 water level changes at some reservoirs, but the changes would have little overall effect on
5992 sediment within Region C for the same reasons discussed above in the Region A discussion
5993 under MO2.

5994 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

5995 **Water Quality**

5996 ***Water Temperature***

5997 Under MO2 and as with No Action Alternative, the four lower Columbia River reservoirs
5998 (McNary, John Day, The Dalles, and Bonneville) would continue to show weak to no
5999 temperature stratification during the summer months largely due to the time water is in the
6000 reservoirs and water mixing that would occur in the reservoirs. Maximum tailwater
6001 temperatures and the frequency of water temperature standard exceedances would be similar
6002 for MO2 and the No Action Alternative over a range of river and weather conditions. Impacts
6003 are expected to be negligible.

6004 ***Total Dissolved Gas***

6005 MO2 model results generally show a decrease in forebay and tailwater TDG saturations and in
6006 the frequency of exceedances of current state TDG standards of 110 percent as compared to
6007 the No Action Alternative. MO2 effects on TDG would be minor at McNary and John Day Dams,
6008 moderate at The Dalles Dam, and negligible at Bonneville Dam based on the logic presented in
6009 Section 3.4.3.2.

6010 ***Other Physical, Chemical, and Biological Processes***

6011 Water quality conditions, as described for the affected environment and the No Action
6012 Alternative, are expected to continue under MO2 for the lower Columbia River.

6013 **Sediment Quality**

6014 Overall, MO2 is expected to have little impact on sediment conditions within Region D and
6015 would be similar to the No Action Alternative.

6016 **SUMMARY OF EFFECTS**

6017 Although the effects of MO2 differ across the various projects in terms of water quality, they
6018 can generally be categorized as follows.

6019 In Region A, MO2 is expected to result in a greater ability for the selective withdrawal system at
6020 Lake Kocanusa and Hungry Horse Reservoir to achieve downstream temperature objectives,
6021 compared to the No Action Alternative. In the Albeni Falls reservoir, there would be a small
6022 water temperature change ranging from about a 0.9 degree Fahrenheit decrease to an increase
6023 of about 2.7 degree Fahrenheit. The small increase in spill at Libby Dam would result in a small
6024 increase in the number of days with TDG exceeding 110 percent. Hungry Horse Dam would
6025 have fewer days exceeding 110 percent TDG compared to the No Action Alternative, and Albeni
6026 Falls TDG levels would remain the same. MO2 may result in some reductions to productivity in
6027 Hungry Horse and Libby Reservoirs, but the alternative would not impact turbidity or sediment
6028 concentrations in the region. Overall, these effects are expected to be negligible to minor.

6029 In Region B, MO2 is expected to result in slight warming in the spring and early summer under
6030 certain flow and air temperature conditions, but in general water temperature effects are
6031 negligible. TDG would decrease at Grand Coulee, particularly in average flow years, by 5 to 10
6032 percent. TDG effects downstream of Chief Joseph Dam are negligible. There may be some
6033 additional mercury mobilization in Lake Roosevelt, but no additional physical, chemical, or
6034 biological water quality parameters are anticipated to change from the No Action Alternative.

6035 In Region C, MO2 is expected to result in negligible water temperature effects. The frequency
6036 when TDG would exceed 110 percent would decrease in August in the lower Snake River due to
6037 reduced spill for downstream fish passage. All other water quality conditions would be similar
6038 to those under the No Action Alternative. Overall, water quality effects in Region C under MO2
6039 are anticipated to be minor to negligible.

6040 In Region D, water temperatures would be similar to the No Action Alternative. TDG
6041 saturations and the frequency of exceeding the state TDG water quality standards would
6042 decrease under MO2. All other water quality parameters are anticipated to be similar to the No
6043 Action Alternative. Overall, there would be a negligible impact to most water quality
6044 parameters and a minor to moderate reductions in TDG conditions.

6045 For further details, please refer to the Water Quality Technical Appendix D.

6046 **3.4.3.6 Multiple Objective Alternative 3**

6047 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

6048 **Water Quality**

6049 ***Water Temperature***

6050 Under MO3, the SWSs at Hungry Horse and Libby would continue to be operational and
6051 therefore, water temperatures management at both projects would continue as that described
6052 in the No Action Alternative. Downstream of Libby Dam, higher November and December
6053 outflows may delay the natural cooling of the Kootenai River downstream of the dam. The
6054 higher outflows in November and December are caused by the *December Libby Target*
6055 *Elevation* measure which, in MO3, calls for a reservoir elevation of 2,400 feet NGVD29 at the
6056 end of the December. This deeper draft to 2,400 feet NGVD29 at the end of December and the
6057 subsequent reservoir levels through the winter, however, may allow for the reservoir to warm
6058 earlier in the spring, providing for earlier (and beneficial) warming to water temperatures
6059 downstream of the dam.

6060 There would be no changes to operations expected at Albeni Falls Dam so the temperature
6061 conditions in Lake Pend Oreille and the Pend Oreille River are expected to remain unchanged
6062 under MO3 and reflect conditions as described in the No Action Alternative.

6063 ***Total Dissolved Gas***

6064 MO3 would modify Libby Dam's draft and refill operations resulting in a small increase in spill
6065 compared to the No Action Alternative. For the 80-year period from 1928 to 2008, model
6066 results predict 5 years when spill would occur under MO3 versus only 2 years when spill would
6067 occur for the No Action Alternative. Of those years with spill, there would be 27 days with TDG
6068 exceeding 110 percent for MO3 versus 8 days of spill exceeding the 110 percent TDG standard
6069 under the No Action Alternative. Regardless, Libby Dam is not expected to spill frequently
6070 under MO3, so downstream TDG saturations should remain less than 110 percent the majority
6071 of time.

6072 Winter and spring Hungry Horse Dam operations are not specifically targeted by any measures,
6073 but due to changes in pool elevations at the end of September from the *Hungry Horse*
6074 *Additional Water Supply* measure and the *Sliding Scale at Libby and Hungry Horse* measure,
6075 winter and spring reservoir elevations and outflows would be impacted. Specifically, outflows
6076 from October through June would be lower under MO3 than the No Action Alternative. TDG
6077 below the dam under MO3 is expected to be relatively similar to the No Action Alternative in
6078 most years. The only exception would be for those years that follow a very dry year in which
6079 Hungry Horse Reservoir would not reach its normal end-of-September elevation; TDG in these
6080 years could be slightly reduced due to reduced outflow and spill (Appendix D).

6081 Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills
6082 most years. Because there are little to no changes in Albeni Falls Dam operations between MO3
6083 and the No Action Alternative, TDG levels under MO3 are expected to remain unchanged.

6084 ***Other Physical, Chemical, and Biological Processes***

6085 The modified operations under MO3 would result in changes in the drafting depth, water
6086 elevations and retention times of Lake Koochanusa and Hungry Horse Reservoir. This could lead
6087 to higher flushing rates and moderate to major reductions in primary and secondary
6088 productivity in the reservoirs. Water quality chemical and biological parameters of concern in
6089 Lake Koochanusa that may be impacted by the MO3's shorter water residence times include
6090 nutrients such as phosphorus and nitrogen, suspended sediments, metals such as selenium, and
6091 phytoplankton.

6092 Water quality conditions of Lake Pend Oreille and the Pend Oreille River described for the
6093 affected environment and the No Action Alternative are expected to continue under MO3.

6094 **Sediment Quality**

6095 The operational measures related to spill control and timing, fish ladder configuration, spillway
6096 configuration, and other changes would not impact sediment movement and would not change
6097 existing sediment conditions in the Columbia River in Region A. Proposed changes to the timing
6098 and magnitude of operational flows also are not expected to impact sediment movement or
6099 existing sediment conditions; the proposed flows would be within the historical range of flows.
6100 No changes to sediment quality and current sedimentation patterns in Region A from MO3 are
6101 expected.

6102 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

6103 **Water Quality**

6104 ***Water Temperature***

6105 MO3 water temperatures are nearly identical to conditions under the No Action Alternative in
6106 Lake Roosevelt and the Columbia River downstream of Grand Coulee Dam, with few exceptions.
6107 Many of the MO3 measures (the *Planned Draft Rate at Grand Coulee* measure, the *Update*
6108 *System FRM Calculation* measure, *Lake Roosevelt Additional Water Supply*, and changes to
6109 inflow due to changes to upstream projects) would impact winter and spring storage and
6110 outflow; however, the measures are not expected to impact temperatures significantly.
6111 Spring/early summer water temperatures downstream of Grand Coulee Dam would increase
6112 slightly (on average, 0.3 degree Fahrenheit for the period of May through July) in the driest of
6113 years. Overall, negligible water temperature effects below Grand Coulee Dam are expected
6114 under MO3.

6115 Changes to Grand Coulee Dam outflows would carry downstream through Rufus Woods Lake
6116 and Chief Joseph Dam. Modeled temperatures under MO3 Alternative at Chief Joseph Dam

6117 tailwater are similar to, or slightly cooler, than the No Action Alternative with the majority of
6118 temperature differences in the ± 0.5 to 2 degrees Fahrenheit range. Tailwater temperatures
6119 under MO3 are predicted to exceed the Washington State standard of 63.5°F (17.5°C) as
6120 measured by the 7-day average of the daily maximum temperature in August and September,
6121 similar to No Action Alternative. Water temperature changes downstream of Grand Coulee and
6122 Chief Joseph dams are negligible under MO3.

6123 **Total Dissolved Gas**

6124 Downstream of Grand Coulee Dam, major reductions in overall TDG would occur in the
6125 spring/early summer due to the *Update System FRM Calculation and Lake Roosevelt Additional*
6126 *Water Supply* measures. The operational measure *Grand Coulee Maintenance Operations*
6127 reduces the hydraulic capacity through the power plants, and if examined independently,
6128 would increase occurrence and magnitude of spill. This measure, however, is largely offset in
6129 the spring and early summer by other measures (including effects to inflows from changes in
6130 upstream dam operations combined with the Lake Roosevelt Additional Water measure).
6131 Additionally, the *Contingency Reserves During Fish Passage Spill* measure would allow reserves
6132 to be carried as part of juvenile fish passage spill in the lower Snake and Columbia River
6133 projects, potentially allowing Grand Coulee to generate more and hold less units in reserve,
6134 thus reducing TDG.

6135 At Chief Joseph Dam, the MO3 forebay TDG saturations are predicted to be similar to the No
6136 Action Alternative under a wide range of flow and air temperature conditions. The number of
6137 days the tailwater exceeds the 110 percent TDG criteria is predicted to be similar to or slightly
6138 lower under MO3 depending on flow and meteorological conditions (Appendix D). TDG effects
6139 downstream of Chief Joseph Dam under MO3 are negligible as compared to the No Action
6140 Alternative.

6141 **Other Physical, Chemical, and Biological Processes**

6142 Qualitative analysis suggests that, when compared to the No Action Alternative, MO3 could
6143 have some slight effects to physical, chemical, and biological processes in Lake Roosevelt. No
6144 effects would be likely to occur in the Columbia River immediately below Grand Coulee.
6145 Operational measures, including the *Update System FRM Calculations and Planned Draft Rate*
6146 *at Grand Coulee*, would result in a deeper winter draft in some years as early as January. In
6147 February and March, the reservoir would likely be drafted more slowly (from the *Planned Draft*
6148 *Rate at Grand Coulee* measure), which could reduce local landslides associated with high
6149 turbidity, and thereby improve water quality. Earlier and potentially deeper drafts in some
6150 years would not change the number of occurrences of repeated inundation and exposure of
6151 sediment in comparison to the No Action Alternative but may result in earlier and longer
6152 exposure of sediments. However, earlier and deeper reservoir drawdowns at Grand Coulee
6153 could result in the longer duration and exposure of reservoir shoreline sediment and increase
6154 the potential for mercury solubility in the reservoir water (although the measures would not
6155 change the number of occurrences of repeated inundation and exposure of sediment in
6156 comparison to the No Action Alternative). Increased exposure has the potential to increase

6157 mercury methylation rates, which could lead to greater buildup of mercury quantities in aquatic
6158 organisms (i.e., bioaccumulation) (Willacker 2016), among other potential contributing factors.

6159 Chief Joseph Dam and Rufus Woods Lake elevations and flows under MO3 measures are
6160 predicted to be similar to the No Action Alternative. As such, the water quality of Rufus Woods
6161 Lake under MO3 would be similar to the No Action Alternative. The harmful algae blooms
6162 described for the affected environment and the No Action Alternative would be expected to
6163 continue in the future under MO3.

6164 **Sediment Quality**

6165 Similar to those described for Region A, sediment movement and existing sediment conditions
6166 would remain the same in Region B under MO3 in comparison to the No Action Alternative.

6167 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE** 6168 **HARBOR DAMS**

6169 **Water Quality**

6170 ***Water Temperature***

6171 Water temperature conditions at Dworshak Dam would be very similar under MO3 as
6172 compared to the No Action Alternative. Project operations would not change, and outflow
6173 temperatures would remain less than 54°F year-round.

6174 Breaching the lower Snake River dams under MO3 would produce a major change in the
6175 volume and the amount of heat stored (i.e., heat storage capacity) in the lower Snake River.
6176 Water temperatures would respond accordingly, shifting from a reservoir to river system, with
6177 rapid warming in the spring and cooling in the fall. Based on modeling results, average August
6178 temperatures would be 0.2 degree Fahrenheit less at Lower Granite Dam and 1.8 degrees
6179 Fahrenheit cooler at Ice Harbor Dam, as compared to the No Action Alternative (Appendix D).
6180 Water temperature differences between impounded (No Action Alternative) and non-
6181 impounded river conditions (MO3) would be most notable in the fall and reach largest
6182 differences in November when there would be an average reduction in water temperatures of
6183 3.6 degrees Fahrenheit at Lower Granite Dam and an 8.8 degree Fahrenheit decrease at Ice
6184 Harbor Dam. Maximum summer water temperatures would range from 72°F at Lower Granite
6185 Dam to 76°F at Ice Harbor Dam. The frequency of days when temperatures exceed 68°F would
6186 be highest in July and August and occur up to 45 percent of the time at Lower Granite Dam and
6187 100 percent of the time at Ice Harbor Dam during these two months. Summer day/night
6188 temperature differences that range from 0.5 to 1.0 degree Fahrenheit under the No Action
6189 Alternative would increase to 2.5 to 3.5 degree Fahrenheit, providing nighttime cooling.

6190 ***Total Dissolved Gas***

6191 TDG downstream of Dworshak Dam would be very similar under MO3 when compared to the
6192 No Action Alternative; effects are negligible compared to the No Action Alternative.

6193 TDG above 120 percent could occur at the Lower Snake River dams during the spring prior to
6194 breaching since only three powerhouse units would be available to pass river flow. Remaining
6195 flow would go over the spillways, and the amount of TDG produced would depend on the
6196 spring inflows, but it could exceed 130 percent.

6197 After breaching the dams, there would be no spill and consequently no resulting TDG at the
6198 lower Snake River dams. Plunge pools that could form during development of a stable channel
6199 morphology under the new flow regimen could also produce localized TDG greater than 110
6200 percent for short periods of time.

6201 ***Other Physical, Chemical, and Biological Processes***

6202 The physicochemical and biological processes in Dworshak Reservoir and downstream of the
6203 project would not differ from the No Action Alternative if MO3 is implemented.

6204 Changes would occur to several of the physical and chemical constituents in the lower Snake
6205 River during breaching. Effects would be largest during reservoir drawdown and immediately
6206 following breaching. Suspended solid concentrations are expected to peak to more than 24,000
6207 mg/L during the first breach (Lower Granite and Little Goose) and 16,000 mg/L during the
6208 second breach (Lower Monumental and Ice Harbor). Concentrations greater than 5,000 mg/L
6209 would last for 26 and 18 days during the first and second dam breaching events, respectively
6210 (Section 3.3, River Mechanics). Because the sediments and the interstitial waters (water
6211 between the sediment particles) are deprived of oxygen in the reservoir, they would create an
6212 oxygen demand when the oxygen-deprived water and sediment enter the water column during
6213 breaching, resulting in very low oxygen and even anoxic (no oxygen) conditions during reservoir
6214 drawdown and breach (Annex C). Water column concentrations of nitrogen and phosphorus
6215 would also increase as interstitial water is mixed with the river water during breaching, with
6216 total ammonia-nitrogen (a gaseous combination of hydrogen and nitrogen) the primary
6217 constituent of concern. Ammonia concentrations could exceed the EPA's aquatic life ambient
6218 water quality criteria for chronic toxicity as sediment is mixed with river water. Average
6219 ammonia elutriate concentrations for the four lower Snake River reservoirs in 1997 (Corps
6220 2002) ranged from 2.5 to 3.6 mg/L, with some individual values exceeding 12 mg/L. Although
6221 actual water column concentrations would differ from elutriate concentrations, this data
6222 suggests that there is a potential for ammonia toxicity under MO3. A more concise estimate of
6223 the magnitude, duration, and frequency of possible in-water ammonia concentrations and
6224 resulting toxicity to fish would require additional sediment characterization coupled with
6225 fate/transport modeling. Oxygen and nutrient concentrations would normalize as suspended
6226 solids decrease to No Action Alternative levels. Intermittent oxygen deficits and nutrient pulses
6227 could occur for years after breaching, depending on the hydrologic and biotic processes at the
6228 time, and as material from exposed mudflats moves into the river due to slumping or runoff.
6229 However, there is uncertainty regarding these longer term (>2 year) effects.

6230 Primary productivity would change from a system based on phytoplankton to attached benthic
6231 algae. During, and for some time after breaching, phytoplankton productivity would decrease
6232 as a result of increased suspended solids concentrations and reduced light transparency.

6233 Current attached benthic algae communities would be exposed to air and desiccate. The
6234 transition phase to return the substrate to sand, cobble, and gravel could take years depending
6235 on runoff, location, and precipitation. After a new equilibrium of sediments is established,
6236 primary production would be expected to be higher per length of river than it was during
6237 impoundment under the No Action Alternative.

6238 Secondary production would also change in the lower Snake River if MO3 were implemented.
6239 Zooplankton would become minor components of the food web, and aquatic insect larvae
6240 would become the main secondary producers.

6241 **Sediment Quality**

6242 MO3 would include breaching the four lower Snake River dams. This alternative would have a
6243 major impact on sediment processes within the Snake River. The dam breaching process would
6244 release a large volume of currently shoaled (buildup of sediment into shallow areas) sediment.
6245 The release of this sediment would cause both short-term effects (loss of dissolved oxygen, very
6246 high suspended solids, smothering of downstream aquatic organisms) and longer-term effects
6247 (changes to bioaccumulation of pollutants in aquatic organisms, long-term changes to bank
6248 erosion and groundwater discharges, changes to shoaling patterns within the lower Snake
6249 River). However, it should be noted that the sediment study did not include existing bridges and
6250 therefore does not consider bridge-related scour and deposition potential. Overall, the
6251 sediment in the lower Snake River would move downstream during and after the dam breach.
6252 The release of the currently shoaled sediment, which contains historical pollutants (pesticides,
6253 dioxins, other human-sourced pollutants and naturally occurring mercury in volcanic soils and
6254 from atmospheric deposition) would impact sediment quality in the lower Snake River
6255 (Appendix D). Future sediment accumulations in the lower Snake River would be limited to
6256 backwater areas and would largely accumulate downstream in the Region D (as discussed
6257 below). See Section 3.3, River Mechanics, for additional discussion of sediment movement.

6258 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

6259 **Water Quality**

6260 ***Water Temperature***

6261 Under MO3 and as with the No Action Alternative, the four lower Columbia River reservoirs
6262 (McNary, John Day, The Dalles, and Bonneville) would continue to show weak to no
6263 stratification during the summer months, largely due to the time water is in the reservoirs and
6264 water mixing. In contrast with the No Action Alternative, day-to-night and day-to-day variability
6265 may be greater in the lower Columbia River under MO3, though it would be far less
6266 pronounced than that anticipated in the lower Snake River (Region C). Maximum tailwater
6267 water temperatures and the frequency of water temperature standard exceedances would be
6268 similar for MO3 and the No Action Alternative, with minor effects expected at McNary, John
6269 Day, and The Dalles Dams and negligible effects expected at Bonneville Dam (Appendix D).

6270 **Total Dissolved Gas**

6271 Under MO3, the *Spring Spill to 120 percent TDG* measure calls for managing juvenile fish
6272 passage spill to not exceed a 120 percent TDG saturation at the tailrace of all four lower
6273 Columbia River dams from April 10 to June 15; there would be no TDG limit in the forebays
6274 under this alternative, resulting in larger amounts of spill at times. Additionally, the *Reduced*
6275 *Summer Spill* measure aims to reduce the duration of summer juvenile fish passage spill at the
6276 lower Columbia River dams, ending summer spill on July 31. As a result, MO3 model results
6277 show, as compared to the No Action Alternative, similar or higher tailwater TDG saturations
6278 April through June and lower TDG saturations in August. At most dams and under most river
6279 and weather conditions, forebay TDG saturations would be similar or lower under MO3 as
6280 compared to the No Action Alternative, especially in the McNary forebay because it would no
6281 longer be receiving elevated TDG from the lower Snake River projects. In general, TDG effects
6282 under MO3 would be minor to negligible in the lower Columbia River.

6283 **Other Physical, Chemical, and Biological Processes**

6284 Breaching of the lower Snake River dams would result in sediment being transported
6285 downstream to the McNary Reservoir, particularly in the years immediately following breaching
6286 (near-term). As a result, short-term major negative effects associated with the sediment
6287 transport would be expected in the McNary Reservoir (Appendix D). Dissolved oxygen, light
6288 attenuation, phytoplankton, zooplankton, and productivity would likely be depressed, while
6289 total suspended solids, turbidity, nutrients, organics, and metals would likely increase. Near-
6290 term transport of silt- and clay-sized particles downstream of McNary Dam may cause similar
6291 effects to the downstream reservoirs, though the effects would likely be much less severe than
6292 in the McNary Reservoir because the majority of coarse sediment is expected to be trapped by
6293 McNary Dam. The near-term increases in suspended sediment and turbidity (and associated
6294 effects) would eventually level off, and more typical seasonal fluctuations would occur long
6295 term in the McNary Reservoir and further downstream (Section 3.3, River Mechanics). Long-
6296 term increases in the estimated volumes of silt- and clay-sized particles transported to and
6297 downstream of the McNary Reservoir, as compared to the No Action Alternative, create the
6298 potential for increases in total nutrients, metals, and organic concentrations as these
6299 constituents are often associated with finer sediment particles. The magnitude of these long-
6300 term effects would reflect inflows after the system equilibrates as well as watershed land use
6301 practices and runoff events. The sediment shoaled behind the lower Snake River and McNary
6302 Dams has not been sampled in over 20 years, and there is uncertainty in the chemical
6303 characteristics of the sediment.

6304 **Sediment Quality**

6305 With the exception of the area upstream of and in the McNary Reservoir, there would be no
6306 impact to sediment movement or condition in the lower Columbia River in Region D. Sediment
6307 movement and existing sediment conditions would remain the same at John Day, The Dalles,
6308 and Bonneville Dams in Region D under MO3. As discussed for Region C above, the sediment in
6309 the lower Snake River would move downstream during and after the dam breach. The release

6310 of the sediment, which contains historical pollutants (pesticides, dioxins, other human-sourced
6311 pollutants and naturally occurring mercury in volcanic soils and from atmospheric deposition)
6312 would impact sediment quality in the McNary Reservoir. In the future, the majority of the
6313 sediment moving through the lower Snake River would accumulate within the McNary
6314 Reservoir with a smaller amount of fine-grained suspended material passing through the dam,
6315 along the lower Columbia River, and out into the estuary. Future sediment accumulation at the
6316 lower Columbia River dams would not be greatly impacted. See Section 3.3, *River Mechanics*,
6317 for additional discussion of sediment movement.

6318 **SUMMARY OF EFFECTS**

6319 Although the effects of MO3 differ across the various projects in terms of water quality, they
6320 can generally be categorized as follows:

6321 In Region A, MO3 would result in water temperatures that would be similar to the No Action
6322 Alternative. TDG levels would be similar to the No Action Alternative, though there may be a
6323 slight reduction in spill and associated TDG at Hungry Horse Dam during very dry years. There
6324 may be a decrease in primary and secondary productivity in the reservoirs. Overall, MO3 would
6325 have a minor effect on water quality in Region A.

6326 In Region B, MO3 water temperatures would be nearly identical to conditions under the No
6327 Action Alternative, with few exceptions. Downstream of Grand Coulee Dam, major reductions
6328 in overall TDG may occur in the spring/early summer. The Chief Joseph Dam forebay TDG
6329 saturations are predicted to be similar to the No Action Alternative under a wide range of flow
6330 and air temperature conditions. Mercury mobilization may occur slightly more frequently in
6331 Lake Roosevelt; no other water quality impairments are anticipated.

6332 Region C would have the largest change in water quality under MO3. Breaching the lower Snake
6333 River dams under MO3 would produce a major change in the volume and the amount of heat
6334 stored in the lower Snake River. Water temperature differences (up to 8.8 degrees Fahrenheit)
6335 between impounded (No Action Alternative) and non-impounded (MO3) river conditions would
6336 be greatest in the fall. TDG downstream of Dworshak Dam would be very similar under MO3.
6337 Due to the breaching, there would be no spill and consequently no resulting TDG at the lower
6338 Snake River dams. However, some elevated TDG would occur during preparation and
6339 implementation of dam breaching. Dam breaching would result in elevated suspended solids,
6340 particularly during and immediately following breaching, which could temporarily result in low
6341 oxygen conditions and elevated ammonia concentrations. Primary and secondary productivity
6342 would also temporarily decrease due to the suspended solids. In the long term, primary and
6343 secondary productivity is anticipated to be greater compared to the No Action Alternative. The
6344 release of sediment during and following the dam breach would also cause both short-term
6345 effects (loss of dissolved oxygen, very high suspended solids, smothering of downstream
6346 aquatic organisms) and longer-term effects (changes to bioaccumulation of pollutants in
6347 aquatic organisms, long-term changes to bank erosion and groundwater discharges, changes to
6348 shoaling patterns within the lower Snake River). Overall, MO3 would have a major short-term
6349 negative impact on water quality due to the mobilization of sediment during dam breaching.

6350 Over the long term, MO3 would have moderate to major beneficial effects on water quality in
6351 Region C through the restoration of natural, river, and water quality processes; a substantial
6352 cooling effect in the fall; greater nighttime cooling and respite from warm water temperature
6353 conditions in the summer; and a reduction in overall system TDG.

6354 In Region D, day-to-night and day-to-day water temperature fluctuations may be greater under
6355 MO3, but the maximum and frequency of water temperatures exceeding state water quality
6356 standards would largely remain the same as the No Action Alternative. Region D would have
6357 similar, though lesser effects as Region C from the dam breaching. TDG levels would be similar
6358 under MO3, though McNary Reservoir would no longer be receiving elevated TDG from the
6359 lower Snake River projects. Sediment and contaminants being transported to McNary Reservoir
6360 during and following the dam breach would result in reduced dissolved oxygen, light
6361 attenuation, phytoplankton, zooplankton, and productivity; while total suspended solids,
6362 turbidity, nutrients, organics, and metals would increase in the short term. Overall, MO3 would
6363 have a moderate short-term negative impact on water quality, particularly in McNary Reservoir
6364 due to the mobilization of sediment during dam breaching. Over the long term, MO3 would
6365 have a negligible to minor beneficial effect on water quality in Region D.

6366 For further details, please refer to the Water Quality Technical Appendix D.

6367 **3.4.3.7 Multiple Objective Alternative 4**

6368 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

6369 **Water Quality**

6370 ***Water Temperature***

6371 Under MO4, the selective withdrawal systems at Hungry Horse and Libby Dams would continue
6372 to be operational and therefore continue to maintain water temperatures at both projects in
6373 manners similar as those described in the No Action Alternative. Changes in water
6374 temperatures downstream of Libby Dam could occur due to the *December Libby Target*
6375 *Elevation* and *Modified Draft at Libby* measures. With these measures, water temperatures
6376 downstream of Libby Dam could be warmer in the winter and colder in the early spring as
6377 compared to the No Action Alternative.

6378 There would be no changes to operations expected at Albeni Falls Dam for median and high
6379 water years under MO4, so the temperature conditions in Lake Pend Oreille and the Pend
6380 Oreille River are expected to remain unchanged and reflect conditions as described in the No
6381 Action Alternative for the median and high flow conditions. For the drier 40 percent of years,
6382 Lake Pend Oreille would be up to 2.6 feet lower in the summer due to higher outflows from
6383 Albeni Falls Dam. Due to this change, it is possible that higher summer flows might increase or
6384 decrease the temperature (ranging from 0.9 to 1.8 degrees Fahrenheit) in the Pend Oreille River
6385 depending on flow and weather conditions (Appendix D).

6386 **Total Dissolved Gas**

6387 TDG below Hungry Horse Dam in the South Fork Flathead River could be affected by multiple
6388 operational measures. All of these measures may result in a deeper drawdown of the reservoir;
6389 however, these reductions would likely occur after the part of the year when spill and
6390 associated high TDG generally occur. TDG may be reduced in dry years subsequent to a large
6391 drawdown in the reservoir under MO4 because the reservoir would enter into the second year
6392 with much less carryover, which could, in turn, result in lower spill from the dam in the early
6393 months of the year. Despite the potential to reduce TDG in these water years, the TDG below
6394 the dam under MO4 is expected to be similar to the No Action Alternative for most conditions.

6395 MO4 would modify Libby Dam's draft and refill operations, resulting in a small increase in spill
6396 compared to the No Action Alternative. For the 80-year period from 1928 to 2008, model
6397 results predict 6 years with spill under MO4 versus only 2 years for the No Action Alternative.
6398 Of these years when spill would occur, 43 days would have TDG exceeding 110 percent for MO4
6399 versus only 8 days exceeding 110 percent TDG for the No Action Alternative. Regardless, Libby
6400 Dam is not expected to spill frequently under MO4, so downstream TDG saturations should
6401 remain less than 110 percent the majority of time.

6402 Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills
6403 most years. Because there are few changes in Albeni Falls Dam operations between MO4 and
6404 the No Action Alternative, spillway operations and TDG conditions under MO4 are expected to
6405 be similar to the No Action Alternative.

6406 **Other Physical, Chemical, and Biological Processes**

6407 The modified operations under MO4 could result in changes in the drafting depth, water
6408 elevations, and retention times of Lake Kootenai. Changes in reservoir elevation and
6409 retention times may result in changes to concentrations of nutrients such as phosphorus and
6410 nitrogen, metals such as selenium, and phytoplankton. This may lead to greater quantities of
6411 selenium and nitrate in Lake Kootenai and the Kootenai River downstream of Libby Dam. The
6412 shorter residence time (amount of time that water stays in the reservoir) may also allow
6413 phosphorus to move farther down reservoir before settling out or transforming. This increase in
6414 nutrients available in the reservoir could make the lake more susceptible to increased
6415 phytoplankton blooms, including potentially toxic species, under MO4.

6416 The decrease in pool elevation and volume during the summer months anticipated under MO4
6417 at Hungry Horse and Libby Reservoirs may result in reduced biological productivity, which could
6418 impact phytoplankton and zooplankton populations that are important food sources for fish. In
6419 addition, the increased outflow under MO4 from both Hungry Horse and Libby Dams could
6420 reduce downstream river productivity with increasing flow from conditions in the No Action
6421 Alternative.

6422 Water quality conditions in Lake Pend Oreille and the Pend Oreille River would be very similar
6423 under MO4 when compared to the No Action Alternative. However, for the drier 40 percent of

6424 years when the lake would be 2.6 feet lower in the summer, the shallow nearshore areas may
6425 be more susceptible to increases in macrophyte and periphyton growth and coverage. In
6426 addition, if there are increases in nearshore nutrients, it is possible that nuisance aquatic
6427 growths may further impair beneficial uses under MO4.

6428 **Sediment Quality**

6429 Many of the proposed actions under MO4 are related to juvenile fish passage. These actions
6430 (changes to fish ladders, screens, intakes, bypass areas) would not impact sediment movement
6431 and would not change existing sediment conditions in Region A. Proposed changes to the
6432 timing and magnitude of operational flows also are not expected to impact sediment
6433 movement or existing sediment conditions; the proposed flows are within the historical range
6434 of flows.

6435 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

6436 **Water Quality**

6437 ***Water Temperature***

6438 From January through March, more empty space is held in Lake Roosevelt under MO4 for the
6439 updated winter space requirements for rain-induced flood mitigation (*Winter System FRM*
6440 *Space*), as well as the decreased draft rate used in planning the drawdown (*Planned Draft Rate*
6441 *at Grand Coulee*). Water temperatures in Lake Roosevelt and downstream of the dam are not
6442 anticipated to change from the No Action Alternative in average and wet water years; however,
6443 in drier years, comparison between MO4 and the No Action Alternative indicates that water
6444 temperatures may increase early in the year below the dam. Similar to the No Action
6445 Alternative, Lake Roosevelt would refill in July in average to wet years; however, in drier years,
6446 when Grand Coulee is managed to support the *McNary Flow Target* measure, the reservoir
6447 would not refill. Rather than being stored, warm water would be passed through the reservoir
6448 in May through July, creating conditions that are 0.8 degrees Fahrenheit warmer, on average,
6449 downstream of Grand Coulee Dam. Late summer temperatures would tend to be slightly (1 to 2
6450 degrees Fahrenheit) warmer, except in the driest/warmest scenario, when model results show
6451 a decrease in temperature. The cause of this impact is likely a combination of changes in
6452 storage timing and outflows and over-simplifying model assumptions. In most years, there
6453 tends to be a rise in water temperature in September under MO4, which coincides with a
6454 reduction in total project outflows that are lower under MO4 as compared to the No Action
6455 Alternative. Water quality standards below Grand Coulee are expected to continue to be
6456 exceeded in August and September, as compared to the No Action Alternative. Overall water
6457 temperature effects downstream of Grand Coulee Dam are expected to be minor.

6458 Flow pattern changes in Grand Coulee Dam outflows would be seen through Rufus Woods Lake
6459 and Chief Joseph Dam, as well as at the tailwater and downstream, under MO4. MO4 water
6460 temperatures at Chief Joseph Dam tailwater are similar to, or slightly warmer, than the No
6461 Action Alternative with the majority of temperature differences in the 1 degree Fahrenheit

6462 range. Tailwater temperatures under MO4 are predicted to exceed the Washington State
6463 standard of 63.5°F) as measured by the 7-day average of the daily maximum temperature in
6464 August and September; this would occur under the No Action Alternative as well. Water
6465 temperature effects downstream of Chief Joseph Dam are minor based on the logic presented
6466 in Section 3.4.3.2.

6467 **Total Dissolved Gas**

6468 There are multiple measures (*Update System FRM Calculation, Planned Draft Rate at Grand*
6469 *Coulee, Winter System FRM Space, Lake Roosevelt Additional Water Supply, Grand Coulee*
6470 *Maintenance Operations, McNary Flow Target*) under MO4 that would result in changed
6471 operations at Grand Coulee Dam.

6472 These operational measures are also included in MO1 with one exception—the addition of the
6473 *McNary Flow Target* measure. During drier years, the *McNary Flow Target* measure would
6474 require the release of up to an additional 2 MAF of water from Lake Roosevelt to help maintain
6475 fish flow objectives in the lower river; 1.0 MAF of that volume is backfilled from Libby, Hungry
6476 Horse, and Albeni Falls Dams during summer. While this would result in changes to outflows,
6477 this measure would not result in increases in TDG from the No Action Alternative at Grand
6478 Coulee Dam as the measure would be implemented in below average flow years, and in actual
6479 operations, spill would be avoided to implement this measure.

6480 The *Winter System FRM Space* measure could result in a deeper draft and larger outflow in the
6481 month of December; however, the difference in TDG response between MO4 and the No Action
6482 Alternative would be similar in this time of year. From January through March, because the
6483 reservoir is lower for the FRM measures, there would typically be lower outflows, and in some
6484 situations, less spill (and corresponding TDG) in those following few months (mid-April to mid-
6485 June). The *Grand Coulee Maintenance Operations* measure has the potential to increase spill
6486 through the reduction in the hydraulic capacity of the powerhouse at Grand Coulee; however,
6487 the other actions under MO4 tend to minimize the effects of these measures on TDG and the
6488 higher TDG that would be associated with this measure is not reflected in modeled results.
6489 Overall, MO4 results in major reductions in TDG downstream of Grand Coulee Dam as
6490 compared to the No Action Alternative.

6491 At Chief Joseph Dam, forebay TDG saturations are predicted to be similar under MO4 as
6492 compared to the No Action Alternative under a wide range of flow and air temperature
6493 conditions. The number of days the tailwater exceeds the 110 percent TDG criteria is predicted
6494 to be slightly lower under MO4 than the No Action Alternative for all flow and meteorological
6495 conditions; TDG effects below Chief Joseph Dam are considered negligible under MO4.

6496 **Other Physical, Chemical, and Biological Processes**

6497 Overall, MO4 operational measures would result in an earlier winter drawdown of Lake
6498 Roosevelt and a larger drawdown in the spring; however, the overall lake level is expected to be
6499 similar to the No Action Alternative lake elevation by July 1. River mechanics analysis indicates

6500 minor increases in the mobility of bed material in Lake Roosevelt under MO4. If contaminated
6501 slag is present in the mobilized bed material, this could create additional toxicity in fish and
6502 other aquatic organisms. However, the change in potential toxicity is unknown. Reservoir
6503 drawdowns of longer duration under MO4 increase the exposure of shorelines. Increased
6504 exposure has the potential to increase mercury methylation rates, which could lead to greater
6505 buildup of mercury quantities in aquatic organisms (i.e., bioaccumulation) (Willacker 2016).

6506 Decreased residence time, associated with higher outflows and reduced residence times when
6507 the *McNary Flow Target* measure is implemented, within the lake could beneficially affect some
6508 areas that are intermittently impaired by algae blooms, such as the section of reservoir where
6509 the Spokane River enters into the reservoir; lower DO in this reach of reservoir was also slightly
6510 improved in low-flow years. The lower drawdown rate associated with operational measure
6511 *Planned Draft Rate at Grand Coulee* could reduce turbidity in the lake due to shoreline erosion.

6512 Chief Joseph Dam and Rufus Woods Lake elevations and flows under MO4 are predicted to be
6513 similar to the No Action Alternative. As such, the water quality of Rufus Woods Lake under MO4
6514 would be similar to the No Action Alternative. The harmful algae blooms described for the
6515 affected environment and the No Action Alternative would be expected to continue in the
6516 future under MO4.

6517 **Sediment Quality**

6518 MO4 operational and structural measures would not impact sediment movement and would
6519 not change existing sediment conditions in Region B. Operational flows under MO4 would be
6520 within the historical range of flows; therefore, sediment conditions are not expected to change.

6521 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE** 6522 **HARBOR DAMS**

6523 **Water Quality**

6524 ***Water Temperature***

6525 Water temperature conditions at Dworshak Dam would be very similar under MO4 as the No
6526 Action Alternative. Short-term differences could occur, but the outflow temperatures would
6527 remain less than 54°F year-round, and reservoir temperatures would not change.

6528 Temperatures at the four lower Snake River projects would be the same under MO4 as the No
6529 Action Alternative, suggesting that water temperatures are not sensitive to the change in spill
6530 from the No Action Alternative in MO4 for the lower Snake River.

6531 ***Total Dissolved Gas***

6532 TDG downstream of Dworshak Dam would be very similar under MO4 when compared to the
6533 No Action Alternative. The primary difference would be some reduction between April and

6534 June, when water is typically released from the dam for flood risk management and refill
6535 purposes.

6536 The *Spill to 125 percent TDG* measure sets juvenile fish passage spill to not exceed 125 percent
6537 TDG saturation, as measured at the tailrace, at all lower Snake River dams from March 1 to
6538 August 31; there is no forebay criteria. Due to the earlier start of juvenile fish passage spill and
6539 the higher tailwater TDG limits, MO4 model results show moderate to major increases in
6540 forebay and tailwater TDG saturations as compared to the No Action Alternative. It should be
6541 noted that there are instances in which TDG does not hit the 125 percent limit. This is primarily
6542 due to the assumptions used to determine spill at the onset of modeling. In real-time, the 125
6543 percent TDG limits could likely be met more often, as long as there was enough water to spill
6544 while maintaining minimum generation at the projects.

6545 ***Other Physical, Chemical, and Biological Processes***

6546 For the projects in Region C, MO4 is not expected to alter other physical, chemical and
6547 biological water quality parameters as compared to the No Action Alternative.

6548 **Sediment Quality**

6549 No changes to sediment quality and current sedimentation patterns in the Region C are
6550 expected as compared to the No Action Alternative.

6551 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

6552 **Water Quality**

6553 ***Water Temperature***

6554 Under MO4 and as with the No Action Alternative, the four lower Columbia River reservoirs
6555 (McNary, John Day, The Dalles, and Bonneville) would continue to show weak to no
6556 stratification during the summer months, largely due to the short residence time, wind and
6557 flow-induced turbulent diffusion, and convective mixing that occurs in the reservoirs. Maximum
6558 tailwater water temperatures and the frequency of water temperature standard exceedances
6559 would be similar for MO4 and the No Action Alternative over a range of river and weather
6560 conditions. Minor effects to water temperature are anticipated downstream of McNary Dam,
6561 while negligible effects are expected downstream of John Day, The Dalles, and Bonneville
6562 Dams.

6563 ***Total Dissolved Gas***

6564 The *Spill to 125 percent TDG* measure sets juvenile fish passage spill to not exceed 125 percent
6565 TDG saturation, as measured at the tailrace, at all lower Columbia River dams from March 1 to
6566 August 31; there is no forebay criteria. Due to the earlier start of juvenile fish passage spill and
6567 the higher tailwater TDG limits, there would be negligible to major increases in forebay and
6568 tailwater TDG saturations as compared to the No Action Alternative, depending on the project.

6569 It should be noted that there are instances in which TDG does not hit the 125 percent limit. This
6570 is primarily due to the assumptions used to determine spill at the onset of modeling. In real-
6571 time, the 125 percent TDG limits could likely be met more often, as long as there was enough
6572 water to spill while maintaining minimum generation at the projects.

6573 ***Other Physical, Chemical, and Biological Processes***

6574 For the lower Columbia River projects in Region D, MO4 is not expected to alter other
6575 physicochemical and biological water quality parameters as compared to the No Action
6576 Alternative.

6577 **Sediment Quality**

6578 No changes to sediment quality and current sedimentation patterns in the Region D are
6579 expected as compared to the No Action Alternative.

6580 **SUMMARY OF EFFECTS**

6581 Although the effects of MO4 differ across the various projects in terms of water quality, they
6582 can generally be categorized as follows.

6583 In Region A, with the exception of Lake Pend Oreille, MO4 water temperatures would largely be
6584 similar to the No Action Alternative. In the Pend Oreille River, during dry years, there would be
6585 a change in water temperatures ranging from a decrease of about 0.9 degree Fahrenheit to an
6586 increase of 1.8 degrees Fahrenheit in the summer, depending on flows and weather. The TDG
6587 below the dams under MO4 are expected to be similar to the No Action Alternative for most
6588 conditions. Minor changes to the physical, chemical, or biological processes in the reservoirs
6589 located in Region A would occur. MO4 would not impact turbidity or sediment concentrations
6590 in the region. Overall, water quality effects in Region A are expected to be negligible to minor.

6591 In Region B, minor water temperature effects between MO4 and the No Action Alternative
6592 would be expected. Major reductions in TDG are expected below Grand Coulee Dam while
6593 negligible effects are expected downstream of Chief Joseph Dam. MO4 operational measures
6594 would result in an earlier winter drawdown of Lake Roosevelt and a larger drawdown in the
6595 spring. This could prolong sediment exposure in the top 10 to 20 feet of the reservoir and
6596 promote a higher rate of mercury cycling. Overall, however, water quality effects in Region B
6597 are expected to be negligible to minor as compared to the No Action Alternative.

6598 In Region C, water temperatures would largely be the same as the No Action Alternative. TDG
6599 downstream of Dworshak Dam would be very similar under MO4 when compared to the No
6600 Action Alternative. Due to the earlier start of juvenile fish passage spill and the higher tailwater
6601 TDG limits, MO4 would have notable increases in forebay and tailwater TDG saturations as
6602 compared to the No Action Alternative. There would be no changes to other water quality
6603 parameters. With the exception of TDG, these effects would have a negligible impact to water
6604 quality. For TDG levels, there would be a moderate to major change as compared to the No
6605 Action Alternative.

6606 In Region D, due to the earlier start of juvenile fish passage spill and the higher tailwater TDG
6607 limits under MO4, there would be notable increases in forebay and tailwater TDG saturations as
6608 compared to the No Action Alternative. There would be minor water temperature effects
6609 downstream of McNary Dam due to summer warming from the *McNary Flow Target* measure;
6610 effects further downstream at John Day, The Dalles, and Bonneville Dam would be negligible.
6611 TDG effects would vary by project with negligible to major changes expected as compared to
6612 the No Action Alternative.

6613 For further details, please refer to the Water Quality Technical Appendix D.

6614 **3.4.4 Tribal Interests**

6615 Water quality concerns vary throughout the basin and include issues caused by operations of
6616 the 14 Federal projects (such as TDG) and issues caused by urban growth, agriculture, pollution,
6617 and industry (Section 3.4.2.1, Water Quality). Some tribes in the study area have water quality
6618 standards that have been approved by EPA. Contamination, be it through impaired water
6619 quality standards, heavy metals coming from upriver mining activities, radioactive sediments
6620 near Hanford, affects Native American people, tribes, and culture.

6621 The water quality analysis (Section 3.4.3) described varying effects of the MOs across the
6622 different regions and projects. The analysis focused on operational effects to TDG,
6623 temperature, and other water quality conditions. MO1, MO2, and MO4 would have varying
6624 impacts on water quality, depending on location (MO3 is discussed below), primarily through
6625 TDG, temperatures, and nutrients (productivity). Of concern for tribal interests are measures at
6626 Grand Coulee. MO2 and MO3 would result in increased exposure of reservoir shoreline
6627 sediment and subsequent increased potential of mercury cycling which could lead to greater
6628 bioaccumulation, particularly between April and July due to the oxidization of metals in
6629 sediments along the exposed shorelines. This may lead to increased fish consumption
6630 advisories for Lake Roosevelt, which would further adversely affect tribes. Water quality effects
6631 may also harm tribal net pen fisheries. MO2 and MO4 may also impact dissolved oxygen levels
6632 near the Spokane Arm, and water quality concerns there are of concern to the Spokane Tribe of
6633 Indians. MOs are not expected to affect sediments near Hanford.

6634 MO3 would result in impaired water quality in the lower Snake River reach (Region C) due to
6635 dam breaching for 2 to 10 years. As described in Section 3.4.3, there would be short-term and
6636 longer-term effects to water quality down to McNary Reservoir and below. There would be

6637 changes in temperature, TDG, and sediments and an increase in total nutrient, metal, and
6638 organic concentrations associated with finer sediment particles. While there would be
6639 significant short-term effects to water quality from dam breaching, the undammed river
6640 through this reach presents a natural flow regime which may be culturally important to tribes.
6641 Many tribes expressed a desire to have the Snake River return to more normative flow
6642 conditions. For them, dam breaching would be culturally meaningful.

6643 Many tribes in the basin have voiced concerns over water quality in the Columbia River.
6644 Studies have shown that tribal people in the Pacific Northwest consume more fish than non-
6645 tribal residents ([https://www.critfc.org/blog/reports/a-fish-consumption-survey-of-the-
6646 umatilla-nez-perce-yakama-and-warm-springs-tribes-of-the-columbia-river-basin/](https://www.critfc.org/blog/reports/a-fish-consumption-survey-of-the-umatilla-nez-perce-yakama-and-warm-springs-tribes-of-the-columbia-river-basin/)), and
6647 consequently, they question whether the national fish consumption rate of 12 ounces per week
6648 for adults used by the United States Food & Drug Administration and Environmental Protection
6649 Agency (2015-2020 Dietary Guidelines for Americans,
6650 <https://health.gov/dietaryguidelines/2015/guidelines/>) is applicable to tribal members.
6651 Furthermore, existing health advisories for fish caught in some stretches of the river reduce the
6652 recommended consumption level considerably:

6653 “The Washington Department of Health (DOH) has issued this fish consumption
6654 advisory for Lake Roosevelt due to mercury contamination: pregnant women,
6655 women of childbearing age, and children under six years of age should eat no
6656 more than two meals of walleye (8-ounce portion) a month”
6657 (<https://wdfw.wa.gov/fishing/locations/lowland-lakes/franklin-roosevelt-lake>).

6658 In their Tribal Perspective submittal, the Confederated Tribes of the Colville Reservation
6659 captured this concern by discussing concerns among its elders:

6660 “Knowing smelter contamination from industrial activities in Trail, B.C. pollutes the
6661 Columbia River; she is hesitant to continue the ways taught to her. She still sweats
6662 intermittently, but fears that by heating the rocks, vaporizing the water, and burning fir
6663 boughs, toxins will be released and she or her family will inhale or ingest them., and that
6664 a human health risk might exist among tribal members from exposure to 2,3,7,8-
6665 tetrachlorodibenzo-p-dioxin (dioxin) and other waterborne toxic contaminants” (See
6666 Appendix P).

6667 Although tribal members rely on fish as part of their daily diet to a greater degree than non-
6668 tribal people, their consumption rates are still a small fraction of their heritage consumption
6669 rates. Many of the tribes referred to this in their Tribal Perspectives. The Coeur d’Alene Tribe
6670 provided a study of their heritage fish consumption rates which asserts “Water quality is of
6671 great importance to the Coeur d’Alene Tribe.” and then provides a number of academic studies
6672 which place heritage consumption rates for tribes of the Columbia basin in general in a range
6673 with a high end of 1,000 pounds of fish per year, per member of the tribe. Today, estimates
6674 place annual consumption at 117 pounds per year, per member (Heritage Fish Consumption
6675 Rates of the Coeur d’Alene Tribes, RIDOLFI Inc. 2016).

6676 Another tribe provided the following: “Shoshone and Bannock peoples consumed
6677 approximately 700 pounds of salmon per person annually, prior to the development of the
6678 System. At present, only 1.2 pounds of salmon are consumed per tribal member annually.” The
6679 Confederated Salish and Kootenai Tribes of the Flathead Reservation in their Tribal Perspective
6680 discuss the importance of fish to their tribal member’s cultural diet, to protect these resources,
6681 and try to return to heritage consumption rates:

6682 “have developed federally-approved water quality standards for the Flathead Indian
6683 Reservation. The CSKT are continuously working to protect and improve the water
6684 quality in Reservation waters, including Flathead Lake, by various means, including:
6685 membership in the Flathead Basin Commission; negotiating with trans-boundary
6686 interests regarding coal development in the North Fork Flathead River; participating in
6687 FERC-relicensing workgroups; implementing Séliš Ksanka Qlispé Hydroelectric Project
6688 (SKQ Dam, formerly Kerr Dam) environmental mitigation requirements; and operating
6689 of a certified Tribal water quality laboratory.” (See Appendix P).

6690 **3.5 AQUATIC HABITAT, AQUATIC INVERTEBRATES, AND FISH**

6691 **3.5.1 Introduction**

6692 This section provides a description of the existing Affected Environment that aquatic species
6693 inhabit in the CRS. This section also evaluates the Environmental Consequences (i.e. effects)
6694 associated with the No Action Alternative, MO1, MO2, MO3, and MO4. Each alternative
6695 evaluated in this EIS balanced multiple objectives (described in Chapter 2) and therefore,
6696 resulted in different effects which are summarized separately. The analytical tools and methods
6697 used by the co-lead agencies to evaluate the environmental consequences of the alternatives
6698 are described in Section 3.5.3.1. This section focuses on the direct and indirect effects of the
6699 alternatives while Chapter 5 discusses additional mitigation and Chapter 6 outlines the
6700 cumulative effects with other actions.

6701 The analysis of environmental consequences performed in this chapter is specific to the
6702 measures developed by the co-lead agencies in conjunction with the cooperating agencies. The
6703 individual measures contained in the multiple objectives do not necessarily reflect full
6704 consensus of the co-lead agencies and cooperating agencies, but were analyzed to consider a
6705 wide range of possible actions and associated consequences or effects (see Chapter 2).

6706 This EIS assesses the impacts of operating and maintaining the CRS while also implementing
6707 actions that address the effects of CRS operations and maintenance and conserve fish and
6708 wildlife. The analysis in the environmental consequences section (3.5.3) focuses on evaluating
6709 the impacts of the EIS alternatives on aquatic species. The co-lead agencies evaluate these
6710 consequences on multiple categories of species including ESA-listed and non-ESA listed, as well
6711 as anadromous and resident species. The co-lead agencies also consider the impacts of the
6712 alternatives on the broader food availability for the affected species, such as impacts to
6713 macroinvertebrate communities.

6714 In general, the distribution and abundance of species affected by the CRS are influenced by a
6715 variety of biotic and abiotic factors that interact with aquatic species at various life stages. The
6716 species described herein use a broad range of habitats depending on life stage, and can thus be
6717 more (or less) sensitive to natural and anthropogenic stressors, only some of which are caused
6718 by CRS operations and maintenance, depending on when and where those stressors overlap
6719 with the species' presence.

6720 For context, it should also be noted that there are a host of other regional entities, in addition
6721 to the CRS co-lead agencies, who are formally engaged in mandated and voluntary actions to
6722 address a wide range of impacts to salmon and steelhead in and around the Columbia Basin and
6723 within areas impacted by the CRS. From 2010 to 2019, NMFS's West Coast Region has
6724 completed over 400 "formal" and "formal programmatic" biological opinions (BiOps) applicable
6725 to actions that impact ESA listed salmon and steelhead in the affected environment. While this
6726 list includes activities undertaken by the co-lead agencies, many of these BiOps address impacts
6727 that are upstream, downstream, or inland from CRS management and non-operational

6728 conservation measures. This also includes related mitigation activities, including non-CRS co-
6729 lead agency activities and impacts:

6730 • Federal and non-federal hydroelectric dam operations and assets and related fish passage,
6731 turbine mortality, predation, migration timing, water levels, habitat blockage, and all
6732 related effects

6733 • Water quality and related impacts of water temperature, total dissolved gas, withdrawals,
6734 storage, irrigation, siltation, pollution, farming, grazing, logging, mining, standards
6735 compliance and enforcement, dredging, berth deepening, and all related effects

6736 • Habitat conservation and land management and related impacts of floodplain management,
6737 road and bridge projects, other construction near water ways, forestry practices,
6738 agricultural practices, marine docking and transportation, and all related effects

6739 • Hatcheries and harvest management and related impacts of competition and interbreeding,
6740 commercial and recreational fish harvest, decadal or year-to-year changes in ocean
6741 environments, drought conditions, hatchery take for propagation, disease and toxics
6742 exposure and all related effects

6743 The region's collective ability to successfully carry out actions that benefit salmon and
6744 steelhead is dependent on many common effects, in combination with the actions included in
6745 the analysis. It is also dependent on sustained compliance with regulatory requirements and
6746 building upon successful implementation efforts to date.

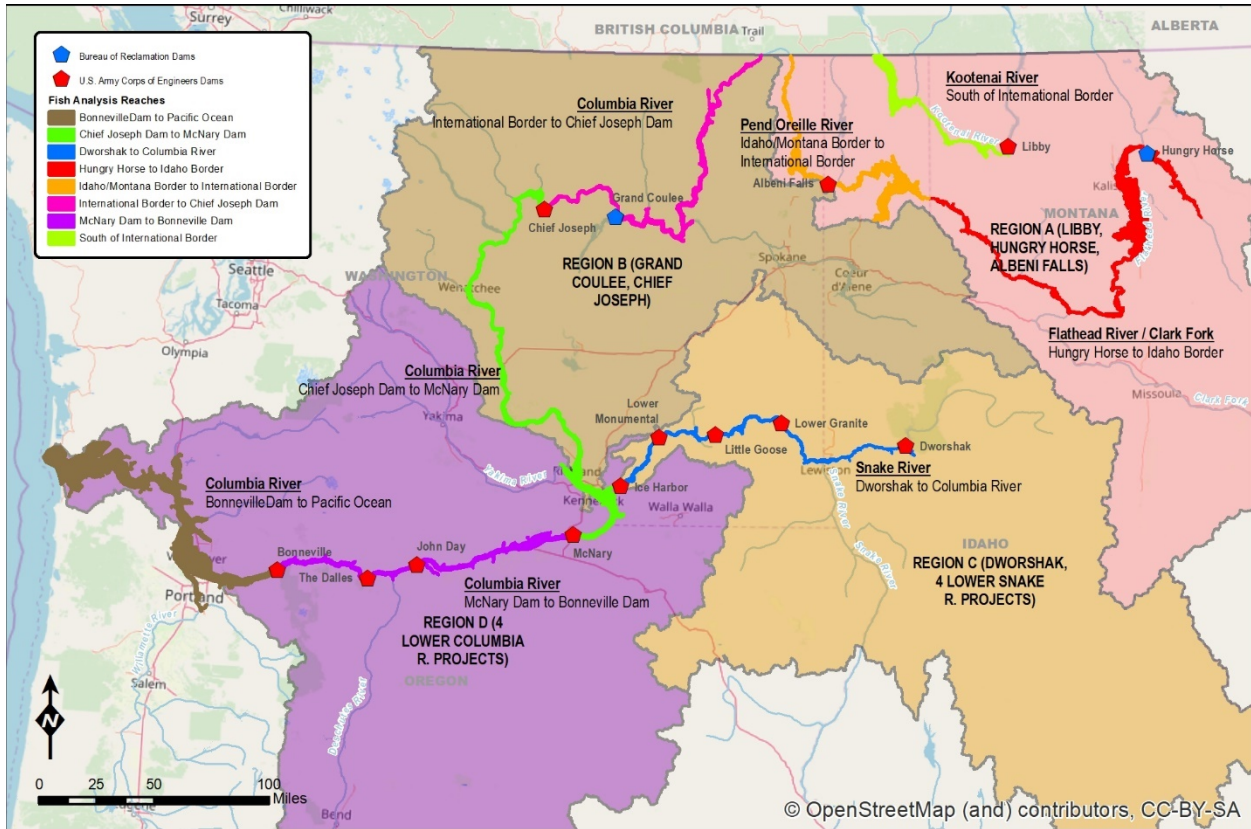
6747 **3.5.2 Affected Environment**

6748 The Columbia River Basin is home to a variety of aquatic organisms, including rare, threatened,
6749 and endangered aquatic species. This section begins with an introduction and background
6750 section, which includes general discussions of the overall study area (Figure 3-109) and a
6751 discussion of past effects. The affected environment includes a description of aquatic habitat
6752 elements, followed by a description of anadromous fish, resident fish, and aquatic
6753 macroinvertebrates that may be affected by the MOs. Existing conditions are described by
6754 species or region, with species-specific details where relevant to the analysis, including
6755 distribution, life history patterns, population status, and habitat requirements. Section 3.5.3,
6756 Environmental Consequences describes the effects of the various MOs on aquatic habitat, fish,
6757 and macroinvertebrates, as compared to the No Action Alternative.

6758 **3.5.2.1 Analysis Area and Background**

6759 The primary area of analysis of effects to fish and aquatic habitats includes the mainstem
6760 Columbia and Snake Rivers as well as the confluences of major tributaries. Potential effects in
6761 Canadian portions the mainstem Columbia, as well as the Kootenai and Pend Oreille rivers
6762 downstream of CRS projects were not considered in this analysis. The effects in this resource
6763 were generally expected to be similar to the effects described on those tributaries in the United

6764 States. Other rivers in the study area are described where measurable changes in the
6765 abundance of salmon, steelhead, lamprey, and other key fish species have altered components
6766 of the ecosystem.



6767
6768 **Figure 3-109. Study Area Map**

6769 Fish are characterized as either anadromous or resident. Resident fish are characterized as
6770 fluvial, adfluvial or non-migratory (see text box).

6771 **What are the Common Fish Life History Forms?**

6772 All fish use some kind of spawning and migration behaviors, often referred to as their “life history strategy.” The
6773 fishes’ life history determines its label of anadromous or resident, and if resident then it can be fluvial, adfluvial, or
6774 non-migratory.

6775 **Anadromous:** As juveniles, fish migrate from freshwater to marine environments and then return to freshwater as
6776 adults to spawn. Eggs incubate in gravel and young fish emerge to rear in freshwater as they migrate downstream
6777 or prior to migration.

6778 **Resident:** The entire life of the fish is within freshwater, in either streams, rivers, or lakes. Some species migrate to
6779 a different freshwater habitat for spawning having fluvial or adfluvial migration patterns, or can be called resident
6780 referring to no migration between spawning and rearing habitats.

6781 **Fluvial:** These fish live entirely within flowing water and may migrate between larger rivers and smaller tributaries.

6782 **Adfluvial:** Adults spawn and juveniles rear in freshwater streams but migrate to lakes for feeding as sub-adults,
6783 then migrate back to flowing water for spawning.

6784 **3.5.2.2 Aquatic Habitat**

6785 Features such as water quantity, quality, depth, velocity, cover, substrate, riparian and aquatic
6786 vegetation, and prey availability are all important components of aquatic environments that
6787 provide habitat for a diverse array of aquatic species. An overview of these features is
6788 described in this section, while species or location-specific features are discussed in individual
6789 species' sections. Water management operations at Columbia River System projects can affect
6790 these aquatic habitat features.

6791 Aquatic habitat in this analysis is defined as all locations in the study area that are accessible to
6792 fish species. The existing conditions of the study area, which includes the 14 Federal dams, are
6793 influenced by surrounding areas and other projects upstream; these other projects are
6794 mentioned where relevant to the habitat under analysis.

6795 Aquatic habitat can be divided into two categories: riverine habitat and reservoir/lake habitat.
6796 Each habitat hosts different species that have adapted to these conditions.

6797 Analysis of the impacts of the MOs on aquatic habitat is described in the effects analyses for the
6798 specific fish species.

6799 **AQUATIC HABITAT CATEGORIES**

6800 **Riverine Habitats**

6801 Rivers meander across their landscapes according to the underlying geological and physical
6802 features of the landscape, surrounding terrain, and dominant weather patterns.

6803 A natural river ecosystem has a relatively stable pool-to-riffle ratio, which determines how and
6804 where the various plants and animals find their supporting habitats in channels and along
6805 shorelines. Riffles are key spawning locations; depth, velocity, and substrate determine
6806 spawning areas for salmon and steelhead, lamprey, and sturgeon. Pools support feeding areas
6807 for juvenile salmon and steelhead and holding areas for adult salmon and steelhead on
6808 upstream migration. Pools and riffles support different communities of invertebrates, which
6809 serve as prey items for fish and help with the important nutrient cycling process of the river
6810 ecosystem.

6811 Along the riverine shorelines, beaches and sandbars form by deposition of suspended sand in
6812 zones of recirculating flow or eddies along the channel margin or by obstacles such as boulders
6813 and large logs in the channel that cause slower velocity water where sediment drops out of
6814 suspension. Juvenile fall-run Chinook salmon favor areas with gently sloping shorelines that are
6815 often associated with beach areas. Tiffan et al. (2006) found that along the Hanford Reach, the
6816 longest free-flowing reach of the Columbia River, subyearling fall-run Chinook salmon were
6817 most likely to occur in habitats with low lateral bank slopes with intermediate-sized gravel and
6818 cobble substrates.

6819 Armoring, bulk-heading, dredging, filling, dock and pier construction, levee construction,
6820 riparian vegetation removal, and urbanization and industrialization have altered shorelines of
6821 importance to juvenile salmon during their freshwater migration downstream to the Columbia
6822 River estuary. Loss of shoreline aquatic vegetation and large woody material has reduced total
6823 habitat available for juvenile foraging, cover to hide from predators, and provision of insects
6824 and other detritus that flow into mainstem areas for food and cover.

6825 In the riverine habitat immediately downstream from many of the dams, variations in flows as a
6826 result of power generation such as peaking and load factoring operations intermittently
6827 inundate and dewater the river shorelines. Downstream areas from storage projects experience
6828 more elevation changes due to peaking and load factoring operation than areas downstream of
6829 run-of-river projects. These river edges are nearly devoid of insect life and are biologically
6830 unproductive. When recolonization of aquatic life occurs during higher flows, subsequent
6831 reduction in flow can cause widespread stranding and desiccation of insects, small fish, and fish
6832 eggs, especially when it occurs rapidly. Flood pulses mimicking the natural flow regime,
6833 however, promote biological production and healthy ecosystems, whereas anthropogenic
6834 modifications of flows in temperate rivers typically reduce production (Junk, Bayley, and Sparks
6835 1989). Intermittent high discharges can scour portions of the main channel, dislodging insects
6836 and their habitat. Frequent scour events below dams limit production in the zone protected by
6837 minimum flow requirements. The varial (drawdown) zone is an area of the upstream ends of a
6838 reservoir or river that is periodically inundated and dewatered as the pool or flow rate changes.
6839 The area typically lacks shoreline vegetation because perennial riparian vegetation or shallow
6840 aquatic vegetation establishment may be impaired and the community structure can diverge
6841 considerably from the reservoir bottom. Recruitment of large wood may be reduced. Historical
6842 habitats had dynamic flow regimes that fostered biological productivity by transporting
6843 terrestrial organic matter and nutrients to the riverine environment. Desiccation or other flow
6844 alternations outside the historical range can lead to less productive habitats. The manipulated
6845 flow regime of varial zones means they lack lasting, quality shallow-water habitat. With the
6846 change in habitat types from a productive, permanently wetted reservoir bottom to
6847 unproductive varial zone, the fish assemblage has also shifted. Desiccation of the river
6848 shorelines reduces aquatic insect populations that require wetted areas to complete their early
6849 life stages.

6850 **Reservoir/Lake Habitats**

6851 Each of the 14 Columbia River System projects has impounded a segment of river, thereby
6852 turning the flowing river into a more lake-like reservoir. Along the mainstem Columbia and
6853 Snake Rivers, about 486 miles of riverine habitat have been converted to lentic (still,
6854 freshwater) or semi-lentic reservoirs (Ebel et al. 1989). Dam construction has caused large-scale
6855 changes in habitat types that result in different species distribution, abundance, assemblages,
6856 suitability, productivity, and predator/prey relationships. These habitat changes have often
6857 favored non-native and/or invasive species that compete with and prey on native species.

6858 Most reservoirs create three different habitat zones (Hjort et al. 1981). The first zone is the
6859 forebay area, which is typically lacustrine (lake-like) habitat. At the upstream end of the
6860 reservoir is a second zone that tends to be shallower and has substantial flow velocities. The
6861 third zone, between the forebay and the upstream end, is a transition area that changes from
6862 riverine at the upstream end to more lake-like in the downstream direction toward the forebay.
6863 Each zone can include several sub-types of habitat; however, most can be characterized as
6864 either backwater (including sloughs and embayments) or open-water habitats (Hjort et al. 1981;
6865 Bennett et al. 1983; LaBolle 1984).

6866 Backwaters and embayments provide comparatively warmer temperatures, finer substrate, and
6867 submergent and emergent vegetation. The non-native resident fish species that spawn in these
6868 areas include bass, crappie, bluegill, pumpkinseed, yellow perch, northern pike, brown and
6869 black bullhead, and carp; for these species, spawning occurs from May through mid-July.
6870 Backwater areas support a greater concentration of zooplankton, which attracts the smaller fish
6871 species. This in turn attracts the larger predatory fish that prey on the smaller fish species.
6872 Open water is deeper, has less structure than the backwater areas, and has a range of water
6873 velocities. Species that spawn in open water include the non-native shad and walleye, as well as
6874 native minnows, suckers, sandroller, and white sturgeon. Non-native invasive predatory fish
6875 that spawn in the mainstem include walleye, bass, and channel catfish. The amount of juvenile
6876 salmonid predation by birds and native and non-native fish around dams depends on multiple
6877 factors. Species, proximity to suitable predator habitat, areas with delayed salmonid migration,
6878 and distance from avian colonies influence rates of predation (Petersen 1994; Venditti,
6879 Rondorf, and Kraut 2000; McHugh et al. 2011; Evans et al. 2016). In the lower Columbia River,
6880 marine mammals prey on adult salmonids and white sturgeon in the tailrace of Bonneville Dam;
6881 long-term trends of predation at Bonneville Dam and effects on populations are tracked
6882 annually (Tidwell et al. 2019). Research to measure and track the number of salmonids eaten by
6883 predators at Columbia River Basin dams and options to manage predation (e.g., predator
6884 removal or hazing to scare them away) is ongoing. General use of the project area by avian and
6885 marine mammal species described is in Section 3.6, Vegetation, Wetlands, and Wildlife.

6886 Most of the native resident species spawn in flowing waters at the headwaters of the reservoirs
6887 or in tributary streams. Some species, however, also spawn in the reservoirs. For instance,
6888 northern pikeminnow will spawn either in flowing water or along gravel beaches in reservoirs
6889 (Wydoski and Whitney 1979). According to GEI Consultants Inc. (2004a), Lake Pend Oreille
6890 continues to provide good rearing habitat for cold water fish species; the Corps carefully
6891 manages Albeni Falls Dam operations to facilitate shoreline spawning habitat for kokanee
6892 salmon.

6893 Project operations influence the lake-like conditions of reservoirs. The relatively shallow run-of-
6894 river reservoirs have short retention times (only a few days) while the storage reservoirs can
6895 have much longer retention times of more than 35 days. In run-of-river reservoirs, water is not
6896 stored so retention time does not change notably under different operations, and short
6897 retention time is conducive to faster travel times for outmigrating juvenile salmonids, which is
6898 beneficial for these species. In storage reservoirs such as Lake Roosevelt, however, retention

6899 time can be an important factor in providing habitat for the reservoir fish. Underwood and
6900 Shields (GEI 2004b) demonstrated that zooplankton density in Lake Roosevelt decreases as
6901 water retention time decreases below 30 days. Zooplankton is the primary food source for
6902 kokanee and for the fry life stage of many fish species. Therefore, dam operations that reduce
6903 water retention time and food availability for fish also reduce the lake's fish carrying capacity.
6904 Water retention time and reservoir elevation are the most important predictor of entrainment
6905 (unintentional passage of fish through turbines or spillways) of fish and nutrients through dams
6906 (McLellan et al. 2008).

6907 As with riverine varial zones described above, biological resources such as plants, invertebrates,
6908 and fish cannot survive the periodic inundation and draining of the shoreline around reservoirs.
6909 These zones are impediments to migration as fish move into and out of tributaries that flow
6910 through the varial zone. This is particularly true in storage reservoirs with significant
6911 drawdowns. Increased flow from tributaries promotes juvenile emigration from streams into
6912 reservoirs, where they encounter a barren landscape with little cover and are particularly
6913 vulnerable to predation. Adults migrating into tributaries also encounter these barren reaches,
6914 which are highly dynamic and often pose physical impediments and render individuals
6915 especially vulnerable to predation. These varial zones are likely a major limiting factor to
6916 adfluvial species, such as redband trout and bull trout.

6917 **AQUATIC HABITAT FEATURES**

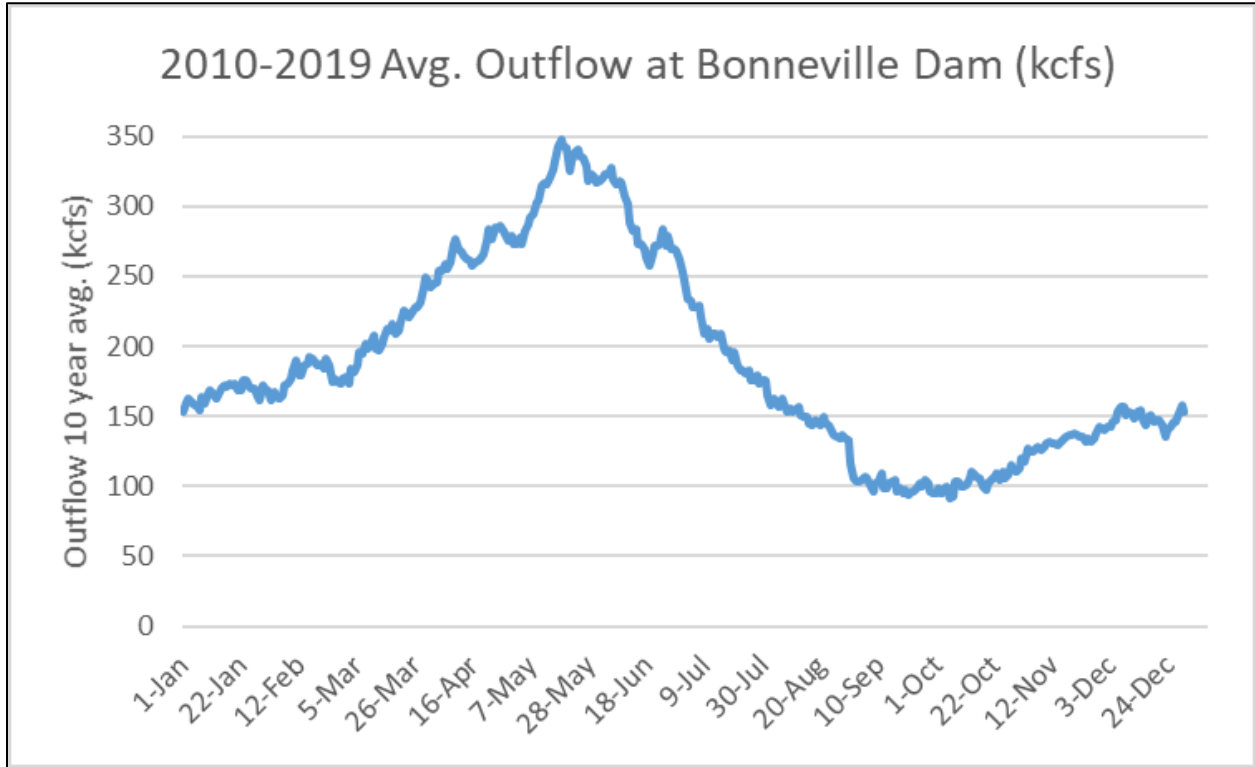
6918 **Water Quantity**

6919 Water resources in the Columbia River System are carefully managed for multiple purposes to
6920 meet requirements for FRM, hydropower, irrigation, navigation, recreation, cultural resources,
6921 and to maintain an ecosystem that supports fish and wildlife. On average, more than 134 Maf
6922 of water flow through the Columbia and Snake River Basins annually. The lower flows each year
6923 occur from September through December, and peak flows occur in May and June with
6924 snowmelt from the higher elevations of the study area (Figure 3-110). An example hydrograph
6925 based on the 10-year average of outflows from Bonneville Dam from 2010-2019 appears below.
6926 For more detail on water flows and timing, see the descriptions in Section 3.2, *Hydrology and*
6927 *Hydraulics*.

6928 Quantity and timing of flows are important for rearing and outmigrating juvenile salmon and
6929 steelhead, temperature regulation in certain river reaches, adult salmon and steelhead
6930 upstream migration, access to and preservation of spawning sites, and tributary connectivity. In
6931 addition, spawning and migratory behavior of resident species is influenced by quantity and
6932 timing of flows.

6933 High spring runoff flows occur from April through June and are critical in moving juvenile
6934 salmon and steelhead out to the ocean. These flows also facilitate spawning behavior and
6935 migratory patterns of resident species such as white sturgeon and redband trout. These same
6936 flows allow adult salmon and steelhead to migrate upriver to natal spawning areas. During low
6937 water years, travel time for outmigrating juvenile salmon and steelhead is increased and

6938 survival reduced. Consequently, some of the water stored in upstream reservoirs is released to
6939 augment high spring flows to assist juvenile fish during outmigration. In addition, water stored
6940 for flow augmentation can be released from July through September to reduce adverse effects
6941 of high water temperatures and improve survival and migration success.



6942 **Figure 3-110. Example Hydrograph Showing the Average Discharge throughout the Year at**
6943 **Bonneville Dam**
6944

6945 **Water Depth**

6946 In some reaches, water depth is critical for fish to leave the mainstem rivers and access
6947 tributary habitat. Timing and quantity of discharge from dams can affect the depth of water for
6948 accessibility of some tributary habitats. One example of this is the minimum tailwater elevation
6949 at Bonneville Dam to allow chum salmon to access tributaries of the Columbia River near Ives
6950 Island.

6951 In reservoirs and in connected floodplain aquatic habitats, the shallower backwater areas host
6952 the greatest abundance of fish in all life stages. Backwater and embayment areas provide
6953 slightly warmer habitat, finer substrate, and submergent and emergent vegetation. In
6954 reservoirs, the duration and depth of substrate inundation as the reservoir refills and drafts
6955 controls the annual production of benthic (bottom-dwelling) insects. Juvenile salmon and
6956 steelhead rear in areas of flowing water shallower than about 5 feet (1.5 meters [m]) and find
6957 bottom-dwelling aquatic insect larvae such as caddisflies, mayflies, and chironomids for food.
6958 Certain types of resident fish use shallow backwater and embayment areas of lakes and
6959 reservoirs.

6960 Deep habitats support fewer fish compared to shallower areas. The majority of the species
6961 found in deeper waters are suckers and minnows; white sturgeon occur in deeper waters as
6962 well. Mid-depth habitats support a community higher in species diversity and abundance than
6963 deep habitat, but lower in abundance than shallow habitat (Bennett et al. 1991). In storage
6964 reservoirs, pelagic species such as kokanee occupy deeper habitats, exploiting rich zooplankton
6965 communities and production occurring within the euphotic zone (i.e., the depth in which
6966 sunlight penetrates).

6967 **Water Velocity**

6968 The habitat factors that influence water velocity are gradient, roughness, width, and depth of
6969 the river channel, lake, or reservoir. Roughness is determined by substrate coarseness such as
6970 sand, cobbles, or boulders, as well as any vegetation or other structures that affect flow. These
6971 habitat factors affect which species will use a given area of aquatic habitat. In the management
6972 of the 14 projects of the Columbia River System, water managers can control velocity to some
6973 extent through holding water or releasing it through the operating projects.

6974 Water velocity and volume play a key role in the life cycle of salmon and steelhead and many
6975 other species. Water flow affects migratory movements of fish downstream and upstream. The
6976 timing of many runs of anadromous salmon and steelheads corresponds with peak flow (Collins
6977 1892).

6978 Decreased flow affects juvenile and adult migratory travel time, which increases their exposure
6979 to predation, elevated water temperatures, greater susceptibility to disease, and other sources
6980 of mortality and injury.

6981 Water velocity also is a key factor in determining aquatic macroinvertebrate communities,
6982 which in turn determines whether fish can find an adequate quantity and variety of prey items.
6983 For example, the macroinvertebrates that are able to cling to rocks and graze algae can remain
6984 in faster-flowing water compared to the species that burrow into sand where water moves
6985 slower and deposits organic litter.

6986 **Retention Time**

6987 The retention time (RT) of a reservoir is the average time a water molecule will spend in that
6988 reservoir. RT is a theoretical value calculated as the ratio of reservoir volume to average flow
6989 (either inflow or outflow). The RT in a reservoir or lake is important because it influences
6990 several lake and reservoir behaviors including stratification (increasing with increasing retention
6991 time) and retention of nutrients (Straškraba 1999). When RT is short, the entire reservoir could
6992 become a riverine zone; when the RT is long it can be a more lacustrine (lake) zone (Straškraba
6993 1999). Reduced retention times can result in increased entrainment of fish and food source out
6994 of the reservoir.

6995 **Water Quality**

6996 ***Temperature***

6997 Native fish species of the Columbia River Basin are adapted to cold flowing water, although
6998 some persist in slightly warmer temperatures in the lakes and reaches of the larger rivers. Each
6999 species and life stage can have a different range of tolerable and optimum temperatures. Most
7000 native species in the Northwest are cold water fish, and the introduced (non-native) species are
7001 warm water fish that tolerate and often thrive in the altered temperature regime that can be
7002 stressful for the native fish.

7003 Warmer water temperatures generally occur in late summer and fall. These warmer
7004 temperatures increase the risk of native fish disease and mortality, affect their toxicological
7005 responses to pollutants, and can affect migratory movements because they can increase the
7006 body temperature of the fish. Water temperatures can be too cold, particularly in tailwater
7007 environments. These conditions may limit growth and productivity. Water temperatures can be
7008 influenced by a variety of factors including habitat, surface air temperatures, and water
7009 storage, inflows, reservoir surface area, solar radiation absorption, and diversions (Section 3.4,
7010 Water Quality).

7011 Fish can move from an unsuitable water temperature into a cooler area to maintain control
7012 over body temperature. If available, juvenile and adult salmon will occupy water that is 13°C to
7013 18°C, with the warmer water selected only when excess food is available. Water temperatures
7014 of approximately 23°C to 25°C can be lethal to salmon and steelhead, and salmonid eggs can
7015 die above 11°C (EPA 2001). Cold water refuges are areas in which the water temperature is
7016 colder than the predominant river temperature. These areas are important for salmon and
7017 steelhead as they migrate upstream, often in the warmest months of the year (EPA 2019). The
7018 Columbia River Cold Water Refuges Project, coordinated by the EPA, is designed to identify the
7019 cold water refuges currently available for use by migrating salmon, assess the sufficiency of the
7020 refuges for current and future populations, and identify strategies to restore, enhance, and
7021 protect high quality refuges for the future.

7022 Dams and reservoirs can change water temperature through their effects on water velocity,
7023 water storage, water diversion, and irrigation return flows. The operation of dam and reservoir
7024 projects, withdrawal of surface waters for irrigation, and pumping of groundwater for irrigation
7025 alter the flow regime, most notably by dampening peak flows and impounding water and, thus,
7026 can influence water temperatures in the Columbia River System project areas. In some cases,
7027 water becomes warmer, and in other cases, cold water can be released from a project to
7028 reduce water temperatures downstream in the system such as from Dworshak Dam.

7029 Surface waters in reservoirs can be warmed by the sun and air temperatures. However, water
7030 deeper in reservoirs, remains cold. Choices in operations, limited by the dam's configuration,
7031 can result in warm or cold water being released. Specifically, at Dworshak, Libby, and Hungry
7032 Horse Dams, selective withdraw depth gates area used to influence downstream water
7033 temperatures. These cold water releases are beneficial since historical temperatures in the

7034 lower Snake River basin prior to the construction of the lower Snake River dams and the Hells
7035 Canyon Complex show that temperatures in the free-flowing lower Snake River often exceeded
7036 20°C in July and August and occasionally exceeded 25°C.¹The warmer water temperatures
7037 occurring in late summer and fall, from a variety of factors, increase the risk of native fish
7038 disease and mortality, affect their toxicological responses to pollutants, and can affect
7039 migratory movements. Warmer water temperatures increase the foraging rate of predatory fish
7040 and help support habitat beneficial to invasive predatory fish. In fact, water temperature is
7041 probably the most important physical variable affecting the consumption rate and growth of
7042 predatory fishes (Brett 1979). For example, laboratory experiments demonstrated maximum
7043 consumption of salmon and steelhead prey increased from 0.5 smolts per day at 8.3°C to seven
7044 smolts per day at 21.7°C (Vigg and Burley 1990).

7045 ***Dissolved Oxygen***

7046 Dissolved oxygen (DO) is a critical water quality component for all aquatic life. The daily cycling
7047 of photosynthesis and respiration is chiefly responsible for fluctuations in DO concentrations.
7048 Most aquatic animals need a minimum of five parts per million (ppm) of DO in water, although
7049 some species like carp, which are non-native in the system, can tolerate lower levels. The deep
7050 areas of reservoirs with high water retention times and limited vertical mixing can become
7051 oxygen depleted, which is harmful to fish and macroinvertebrates. During late summer of some
7052 years, high water temperatures (20°C to 22°C) and low DO levels (less than 6 ppm) have
7053 potential to cause direct mortality or deteriorate living conditions for native species in the
7054 Columbia River Basin.

7055 ***Total Dissolved Gas***

7056 Plunging water over waterfalls, cascades, or dam spillways can cause downstream waters to
7057 become supersaturated with dissolved atmospheric gases referred to as supersaturated total
7058 dissolved gas (TDG), resulting from the entrainment of air bubbles into plunging water. The
7059 primary gases making up TDG pressure in water are oxygen, nitrogen, argon, and carbon
7060 dioxide. High TDG levels in water may persist for many miles downstream from their source.
7061 Elevated TDG can cause gas bubble trauma (GBT) in aquatic organisms, resulting in injury or
7062 death. GBT is an acute condition involving the growth of bubbles in the vascular system of the
7063 fish. Extreme cases of GBT are lethal. Dam operators try to control TDG by reducing spill to
7064 achieve less gas saturation in water. However, the severity of TDG supersaturation decreases by
7065 approximately 10 percent for every meter of water depth due to pressure. Migrating
7066 anadromous fish are typically quite mobile and may sound where adequate water depth is
7067 available decreasing both the severity and duration of TDG exposure below dams.

¹ Peery, C.A. and T.C. Bjornn. 2002. Water Temperatures and Passage of Adult Salmon and Steelhead in the Lower Snake River. Technical Report 02-1. U.S. Geological Survey, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho.

7068 At the Lower Snake and Columbia River dams, spill is used to pass juvenile salmon downstream,
7069 limited the spill volume that produces 120 percent TDG saturation in the tailrace. Thus, TDG
7070 levels during April through June are 115 percent-120 percent throughout this reach as
7071 permitted by Oregon and Washington waivers to the Clean Water Act. Spill levels are lower in
7072 July and August at some dams, and the extent of high TDG waters is therefore reduced as well.

7073 During high river discharges, uncontrolled spill can cause spill in excess of 120 percent TDG.
7074 Dam operators target certain operations intended to reduce adverse impacts, and to meet
7075 Clean Water Act limits of TDG by reducing spill or using certain spill patterns to achieve less gas
7076 saturation in water. The co-lead agencies have also constructed structural components of the
7077 dams in order to reduce adverse impacts of TDG, e.g. spillway flow deflectors.

7078 ***Pollutants***

7079 The major pollutants in the Columbia River Basin are released from the adjacent landscape
7080 through urbanization and agricultural use of pesticides, fertilizers, and herbicides, as well as
7081 legacy contaminants from mining and industrial practices. On water activities such as
7082 navigation and recreation can also release contaminants. Oils and grease necessary for turbines
7083 and other machinery at the dam can leak into the river. The Corps and Reclamation applied for
7084 National Pollutant Discharge Elimination System permits for discharges of pollutants, including
7085 oil or grease, from appropriate point sources. These releases have resulted in increased
7086 pollutant loads moving through the Columbia River Basin, as well as lingering in settled
7087 sediments or by accumulation within resident plant and animal communities. Pollutants can
7088 disperse downstream through the Columbia River dams; some pollutants settle out when water
7089 slows down at a reservoir and others travel all the way to the estuary. Passing by a greater
7090 number of dams increases the chance of pollutants settling out and becoming part of the
7091 sediment.

7092 ***Turbidity***

7093 Turbidity is an indicator of the amount of suspended particles in water. The particles are usually
7094 fine sediments of sand, silt, or clay but can be organic compounds such as plankton. Fish
7095 require specific levels of sediment and turbidity to hide from predators, but they also require
7096 clear waters to find their prey and have optimal gill function. The various native species in the
7097 Columbia River System have different ranges of tolerance for turbidity.

7098 Flow regulation and the existence of reservoirs reduce turbidity in the rivers where Columbia
7099 River System dams are located. Turbid stormwater is held in reservoirs and released at a slower
7100 rate into clear water, compared to unimpounded rivers. This prolongs the duration of
7101 downstream turbidity, while reducing the intensity of downstream turbidity peaks. Reduced
7102 turbidity allows visual predators, such as smallmouth bass, to more effectively prey on native
7103 fish, such as juvenile salmon and steelhead.

7104 Natural levels of turbidity are an important factor related to sturgeon migration, spawning, and
7105 survival. The reduced turbidity levels in reservoirs were linked to increased predation of white
7106 sturgeon larvae in laboratory studies (Gadomski and Parsley 2005).

7107 **Substrate**

7108 The capacity of any aquatic habitat to support fish and invertebrate populations depends
7109 largely on the substrate characteristics as well as depth and velocity of water, which in turn
7110 influence the size of substrate at the reach scale. The primary transport mechanism for water
7111 column sediment is surface water flow. Higher flows transport larger amounts of sediment with
7112 a wider range of particle sizes and weights while lower flows transport lighter, smaller particle
7113 fractions. Sediment particles settle in areas where flows and velocity decrease, such as
7114 backwater areas and impounded sections of the Columbia River System. Sediments fall out of
7115 suspension at a rate proportionate to their size and weight. This is why substrate in slower pool
7116 and glide habitats typically contains smaller materials than in faster riffle and run habitats,
7117 which often have enough power to keep smaller sediments in suspension.

7118 Each fish species has adapted to spawn and feed in specific substrate types in combination with
7119 water velocity. Spawning substrate size preference varies by species and depends mostly on
7120 size of fish—larger fish can use larger substrates compared to smaller fish. For example, fall
7121 Chinook salmon in the Columbia and Snake Rivers use gravel beds with sediment size ranging
7122 from 1 inch (2.5 centimeters [cm]) up to 12 inches (30 cm) (Geist and Dauble 1998), whereas
7123 cutthroat trout select substrate sizes of 0.2 to 4 inches (0.6 to 10.2 cm) (Bjornn and Reiser
7124 1991).

7125 Sedimentation processes have been altered in the Columbia River Basin because of the
7126 construction of the Columbia River System and other projects. Many of the projects,
7127 particularly the storage projects, have interrupted the natural sorting regime of sediment. The
7128 mobilized bedload can only travel downstream to the next point at which the reduction in
7129 velocity means the river can no longer carry the larger grain sizes. USGS (1984) described
7130 downstream effects of dams showing that sediment concentrations and suspended loads
7131 decreased substantially for hundreds of miles downstream. Additionally, riverbed degradation
7132 varied from slight to 24 feet (7.5 m) deep with a coarsening of bed material and lengthened the
7133 degraded area over time extending to at least 30 years beyond dam construction and as much
7134 as 75 miles (120 kilometers [km]) beyond the dam site. One example of an issue created by
7135 changed sedimentation in the study area is that fine sediments that have accumulated in the
7136 lower 22 miles of the Flathead River have shifted the insect biota from a stonefly and mayfly
7137 assemblage to a midge-dominated community, which affects food availability for fish.

7138 **Aquatic Vegetation**

7139 Aquatic vegetation in rivers and reservoirs can be important habitat features for both fish and
7140 wildlife. Examples of fish habitat provided by aquatic vegetation include aquatic grasses in

7141 shallow reservoir areas providing spawning habitat to species that attach their eggs to
7142 vegetation, or predatory fish using cover to lie and wait for prey.

7143 Much of the aquatic vegetation in the Columbia River, also known as macrophytes, that is in
7144 over-abundance is not native, and in many cases, it is detrimental to native fish communities
7145 through increases in water temperatures, cover for non-native predators, effects on flows, and
7146 tribal fisheries. Invasive aquatic plants are a problem in the basin and are on a trajectory for
7147 worsening unless aggressive management plans are implemented.

7148 Aquatic vegetation as part of the affected environment is discussed further in Section 3.6,
7149 Vegetation, Wetland, and Wildlife.

7150 **AQUATIC HABITAT CONNECTIVITY**

7151 Connectivity, or the ability for aquatic species to access other aquatic habits, is an important
7152 part of species survival. Rivers play a vital role in connecting various terrestrial and aquatic
7153 habitats, and their value to all the plant and animal components of the ecosystem extends well
7154 beyond their surface area. Conversely, isolation of habitats has caused and can further risk
7155 extirpation of all the individuals in the confined space, which reduces overall abundance and
7156 biodiversity. For fish species, connectivity to different types of aquatic habitats is important for
7157 them to complete their chronological life stages, particularly for the anadromous species, which
7158 benefit from accessing the entire river system from the spawning area to the ocean.

7159 The key aspect of longitudinal connectivity in aquatic habitat is the ability of fish to reach each
7160 type of habitat critical to its particular life stages. This primarily applies to the anadromous fish
7161 that travel long distances from the ocean up the large rivers to small tributaries, but also
7162 applies to some resident species that move between tributaries and reservoir habitats that can
7163 become disconnected at lower pool elevations. Longitudinal connectivity is important to
7164 prevent species fragmentation and to provide access to spawning, rearing, and foraging habitat
7165 for migratory fish (Fullerton et al. 2010). Loss of connectivity in the study area has led to the
7166 extirpation of multiple salmon populations and the continued fragmentation of resident fish
7167 populations. Conditions in the headwaters of rivers can have a direct effect on downstream
7168 habitats and organisms (Fullerton et al. 2010). In addition, longitudinal connectivity allows for
7169 transportation of sediment and nutrients in the form of woody debris, food items, and other
7170 organic matter.

7171 Construction and operation of Federal and non-Federal dams in the Columbia River Basin have
7172 impacted longitudinal connectivity by blocking or otherwise affecting migratory fish corridors,
7173 changing stream flow patterns, and altering natural water temperature regimes that in many
7174 areas can cause delay of migration or even form thermal barriers.

7175 Lateral floodplain connectivity in the context of aquatic habitat refers first to the ability of the
7176 river to move water into the adjacent landscape, and second, the ability of aquatic species to
7177 access aquatic habitats such as ponds, wetlands, and side channels. This connection between

7178 the river and its adjacent floodplain areas is important to many fish species to find appropriate
7179 habitat for spawning, rearing, and overwintering life stages. Many of the Columbia River System
7180 projects have eliminated floodplain habitat by inundating side channels and other important
7181 diverse types of habitats, or by altering flow regimes so that those floodplain habitats are no
7182 longer accessible by aquatic organisms.

7183 **3.5.2.3 Anadromous Fish**

7184 The affected environment for anadromous fish (Section 3.5.1) is organized by species in order
7185 to facilitate descriptions common to the species across specific runs throughout the Columbia
7186 River Basin. The environmental consequences analysis for anadromous fish (Section 3.5.2) is
7187 organized differently (Upper Columbia River, Middle Columbia River, Snake River, and Lower
7188 Columbia River) because the effects on those species are similar in these geographic areas.

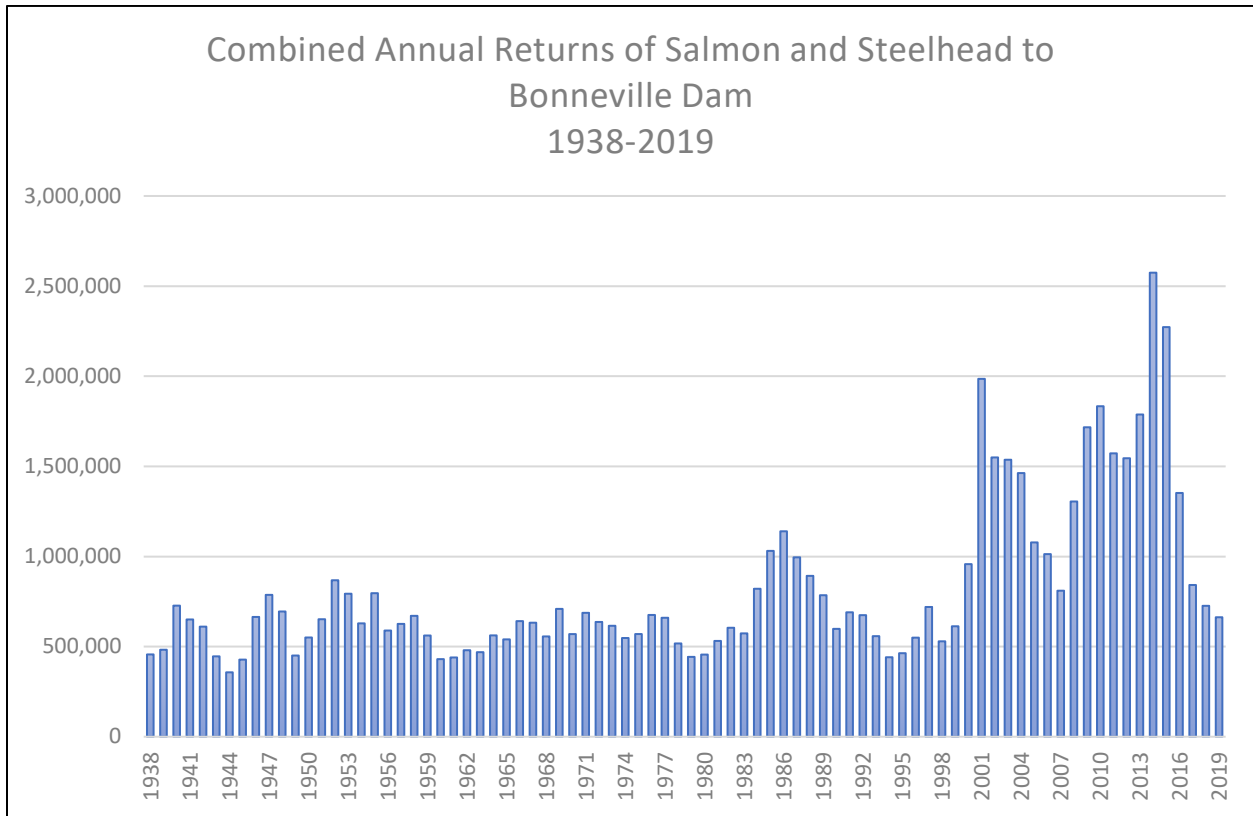
7189 The Columbia River Basin hosts many anadromous fish species. Anadromous fish use
7190 freshwater habitat for spawning and early juvenile life stages before migrating to marine waters
7191 to grow and mature for part of their lifecycle. Among the salmon and steelhead species,
7192 Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), sockeye salmon (*O. nerka*),
7193 and coho salmon (*O. kisutch*) are widespread in the Columbia River Basin. Chum salmon (*O.*
7194 *keta*) has a more limited distribution in estuary tributary streams.

7195 Other anadromous fish include Pacific lamprey (*Entosphenus tridentatus*), eulachon
7196 (*Thaleichthys pacificus*), green sturgeon (*Acipenser medirostris*), and American shad (*Alosa*
7197 *sapidissima*). In addition, white sturgeon (*Acipenser transmontanus*) have a unique physiology
7198 that allows them to move regularly between fresh and saltwater. They are discussed in this
7199 document as resident fish, but the lower river populations are also known to move into the
7200 near-ocean environment to feed. Pacific lamprey have a widespread distribution in the region,
7201 migrating as far as the Clearwater and Salmon River tributaries of Idaho and the Methow
7202 subbasin in the upper Columbia River. Green sturgeon, by contrast, have a relatively limited
7203 distribution in the Columbia River Basin, only migrating upstream to about the city of Longview,
7204 Washington, well below Bonneville Dam. American shad are the only non-native anadromous
7205 species in the Columbia River Basin.

7206 Migratory salmonids are important vectors of energy and nutrients between marine and
7207 freshwater ecosystems. For example, anadromous fish carry nutrients across habitat
7208 boundaries, and they influence community and food web structure in aquatic as well as
7209 terrestrial ecosystems (Gende et al. 2002). Spawning salmon contribute an estimated 5 to 95
7210 percent of the nitrogen and phosphorus in salmon-bearing streams (Gresh et al. 2000).
7211 Anadromous fish deliver resources that affect food web productivity and influence a diverse
7212 array of flora and fauna across vast landscapes in the Columbia River Basin (Naiman et al.
7213 2002).

7214 Anadromous salmon and steelhead returns can vary widely from year-to-year and as shown in
7215 Figure 3-111, as recently as 2014, salmon and steelhead were returning to Bonneville Dam on

7216 their way to upstream tributaries in numbers not been seen in many decades. As the ISAB
7217 noted in 2016 “More salmon returned from the Pacific Ocean and were counted crossing
7218 Bonneville Dam, 146 miles inland, on their way to spawn—at hatcheries or in the wild—in 2014
7219 than in any year since 1938, when fish counting began there. The 2014 run was about 2.5
7220 million fish, continuing the trend of big returns in the 21st Century compared to the 1990’s”
7221 (ISAB, 2015-1). During that same period, NMFS noted in their 2016 5- year status review of
7222 Pacific salmon and steelhead that wild Snake River spring Chinook salmon abundance had
7223 increased over the levels reported in their prior review for most populations, although the
7224 increases were not substantial enough to change viability ratings. NMFS attributed the
7225 relatively high ocean survival in recent years as a major factor in the abundance patterns
7226 leading up to their 2016 review (NMFS, 2016). Although the number of adult salmon and
7227 steelhead has declined since 2014, even with consistent operations of the CRS, and NMFS’s
7228 2020 status review will encompass years with lower returns and declining ocean conditions,
7229 these returns show that salmon and steelhead can pass upstream and downstream through the
7230 system in its current configuration when conditions are suitable.



7231 **Figure 3-111. Combined Annual Salmon and Steelhead Returns (all species) to Bonneville Dam**
7232 **from 1938-2019.**
7233 These returns are a combination of hatchery and natural origin fish. (Data Source: University of Washington-Data
7234 Access Real Time (DART) tool)
7235

7236 On February 4, 2020, the co-lead agencies viewed a presentation prepared by NMFS regarding
7237 returns for the 2019 fish passage season and the Adaptive Management Implementation Plan.²
7238 Although not all returns occurred prior to the presentation, NMFS utilized current return
7239 numbers to project return numbers if current return rates continued in 2020 and 2021. These
7240 projections signaled that returns are low, especially for Snake River steelhead. The co-lead
7241 agencies are currently evaluating the information provided by NMFS and will have a more
7242 detailed discussion of this information in the final EIS, including any updates that NMFS may
7243 provide once all returns have occurred, if appropriate.

7244 To aid the downstream passage of juvenile salmon and steelhead, the co-lead agencies have
7245 worked to improve passage and survival past the dams and through the reservoirs of the CRS.
7246 Figure 3-112, shows recent estimates of survival at the eight lower CRS projects with fish
7247 passage. The dam survival estimates do not include systemwide or latent effects (see section
7248 3.5.3.1). These estimates were developed show progress towards meeting the individual dam
7249 survival goals developed during the 2008 Biological Opinion of 96 percent survival past each
7250 dam for yearling Chinook and steelhead, and 93 percent for Snake River sub-yearling fall
7251 Chinook. In their 2017 analysis of system improvements used for recovery planning analysis,
7252 NMFS concluded that:

7253 “In summary, recent average annual reach survival estimates for migrating smolts have
7254 improved substantially compared to the 1980-2001 Base Period for Snake River
7255 steelhead, yearling spring/summer Chinook salmon, and sockeye salmon (by roughly 50-
7256 75 percent) and compared to the 1998-2005 earlier period for subyearling hatchery fall
7257 Chinook salmon (about 35 percent). As noted in the 2010 Supplemental Biological
7258 Opinion (NMFS 2010; see also Section 2.2.2.2), on a per-kilometer basis, these survival
7259 rates are approaching those estimated for several free flowing river systems. Controlling
7260 for other factors affecting adult returns such as poor ocean conditions, these increased
7261 average survival rates for inriver migrating smolts have resulted in higher adult returns
7262 in recent years compared to the Base Period” (NMFS, 2017).

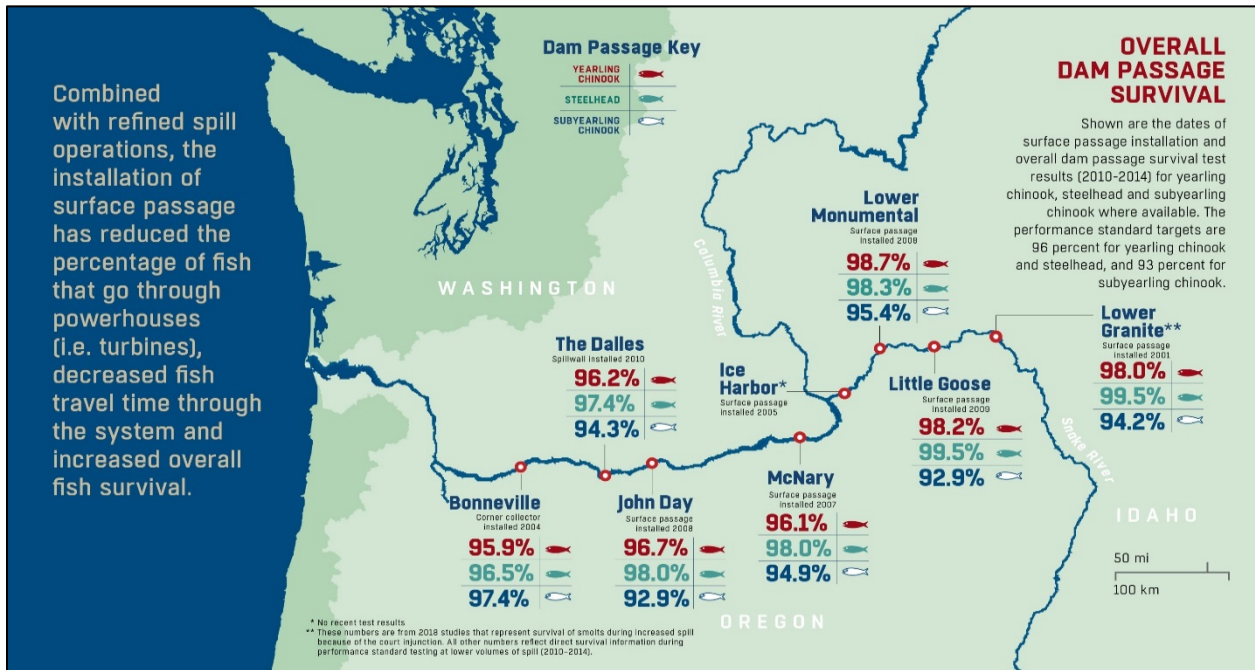
7263 Adult upstream passage through the CRS projects on the lower Columbia and lower Snake
7264 Rivers is generally safe and effective. As NMFS noted in 2017,

7265 “Adult salmon and steelhead can pass each of the eight mainstem dams in the lower
7266 Snake and Columbia rivers volitionally at fish ladders (also called “fishways”). In general,
7267 we consider these adult passage facilities to be highly effective. For example, the
7268 current estimate of average adult Snake River spring/summer Chinook salmon survival
7269 (conversion rate estimates using known-origin adult fish after accounting for “natural
7270 straying” and mainstem harvest) between Bonneville and Lower Granite dams (2012-

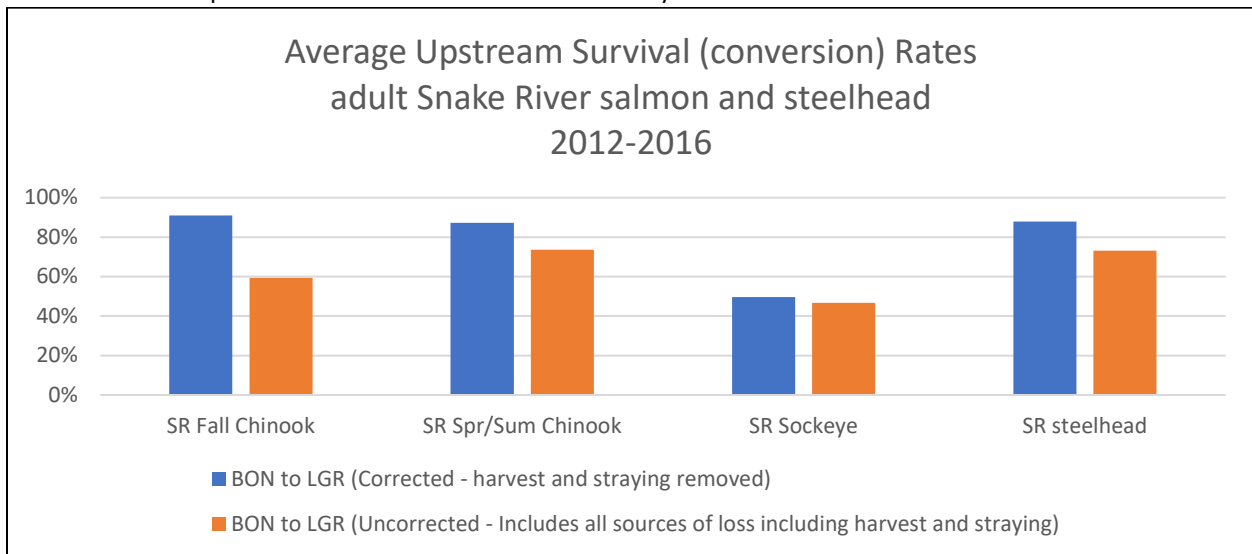
² The Adaptive Management Implementation Plan (AMIP) was a component of the 2010 and 2014 NMFS Supplemental BiOps and 2019 NMFS CRS BiOp and included triggers for: (1) unexpected declines in adult abundance and (2) environmental disasters or environmental degradation (either biological or environmental) in combination with preliminary abundance indicators. If certain triggers are met, the co-lead agencies would work with NMFS and other regional salmon managers to coordinate on a regionwide diagnostic effort to take an appropriate response.

7271 2016) is approximately 87.3 percent, or 73.7 percent when harvest and straying are
 7272 included” (NMFS, 2017)

7273 Figure 3-113 displays the trends described by NMFS for Snake River stocks and reflects the
 7274 combination of passage, straying, and harvest. Once adult salmon and steelhead pass the
 7275 furthest upstream dam in their migration, there may continue to be losses influenced by a
 7276 combination of many factors including natural mortality, water quality, straying, and harvest.



7277 **Figure 3-112. Recent Estimates of Dam Survival at Columbia River System Projects**
 7278 Note: These dam-specific survival estimates do not include systemwide or latent effects.
 7279



7280 **Figure 3-113. 2015–2019 Snake River Spring/Summer Chinook Salmon Upstream Survival**
 7281 **Rates**
 7282 Figure is based on data from NMFS (2017).
 7283

7284 **ENDANGERED SPECIES ACT–LISTED ANADROMOUS FISH**

7285 An inventory of the ESA-listed anadromous species and their designated critical habitat in the
7286 study area appears in Table 3-57. Details on distribution, population status, and threats to each
7287 of these species appear in the *Federal Register* notices that National Marine Fisheries Service
7288 (NMFS) and the U.S. Fish and Wildlife Service (USFWS) provide for all listing actions; these are
7289 cited in the table. Species status and relevant CRSO study area information appears in their
7290 respective subsections later in this section.

7291 **What are Evolutionarily Significant Units and Distinct Population Segments?**

7292 ESA-listed fish species may be identified as an evolutionarily significant unit (ESU) or a distinct population segment
7293 (DPS). Scientists developed the concepts of ESU and DPS to define a listable population unit according to ESA policy
7294 for Pacific salmon (56 *Federal Register* [FR] 58612).

7295 An ESU or DPS is a vertebrate population or group of populations that meet certain criteria of being discrete or
7296 isolated from other populations of the species and significant to preservation of the genetic diversity of the species
7297 (61 FR 4722). These designations can apply to populations within the species if these conditions occur: (1) they are
7298 substantially isolated from other populations of the same species due to physical, physiological, ecological, or
7299 behavioral separation; and (2) the population or group represents an important component required to maintain
7300 conservation of genetic diversity of the biological species per the ESA regulations (61 FR 4722). Typically, DPS is
7301 used for steelhead and inland species, and ESU applies to salmon.

7302 **Table 3-57. Status and Critical Habitat of Anadromous Columbia River Basin Endangered**
7303 **Species Act–Listed Species**

Species and ESU or DPS		ESA Listing Status	Critical Habitat Designation
Chinook salmon	Upper Columbia River Spring-run ESU (<i>Oncorhynchus tshawytscha</i>)	Endangered 1999	2005
	Snake River Spring/Summer-run ESU (<i>O. tshawytscha</i>) ^{1, 2/}	Threatened 1992	1993
	Snake River Fall-run ESU (<i>O. tshawytscha</i>) ^{1/}	Threatened 1992	1993
	Lower Columbia River ESU (<i>O. tshawytscha</i>)	Threatened 1999	2005
	Upper Willamette River ESU (<i>O. tshawytscha</i>)	Threatened 1999	2005
Steelhead	Upper Columbia River DPS (<i>O. mykiss</i>)	Endangered 1997; re-classified to threatened 2006	2005
	Snake River Basin DPS (<i>O. mykiss</i>) ^{2/}	Threatened 1997	2005
	Middle Columbia River DPS (<i>O. mykiss</i>)	Threatened 1999	2005
	Upper Willamette River DPS (<i>O. mykiss</i>)	Threatened 1999	2005
	Lower Columbia River DPS (<i>O. mykiss</i>)	Threatened 1998	2005
Coho salmon	Lower Columbia River ESU (<i>O. kisutch</i>) ^{3/}	Threatened 1999	2016

Species and ESU or DPS		ESA Listing Status	Critical Habitat Designation
Chum salmon	Columbia River ESU (<i>O. keta</i>)	Threatened 1999	2005
Sockeye salmon	Snake River Basin DPS (<i>O. nerka</i>) ^{4/}	Endangered 1991	1993
Eulachon	Southern DPS (<i>Thaleichthys pacificus</i>)	Threatened 2010	2011
Green Sturgeon	Southern DPS (<i>Acipenser medirostris</i>)	Threatened 2006	2009

- 7304 1/ State-listed threatened: Oregon (Oregon Administrative Rule [OAR] 635-100-0105).
 7305 2/ State-listed threatened: Idaho (Idaho Administrative Procedures Act [IDAPA] 13.01.06).
 7306 3/ State-listed endangered: Oregon (OAR 635-100-0105).
 7307 4/ State-listed endangered: Idaho (IDAPA 13.01.06).
 7308 5/ State-listed species of concern: Montana (Montana Fish, Wildlife and Parks [MFWP] 2018).

7309 **Salmon and Steelhead**

7310 Considerable scientific literature is available on ESA-listed salmon and steelhead species in the
 7311 Columbia River Basin, including the life history of these species, how fish migrate through
 7312 Columbia River System projects to and from the ocean, migratory timing, abundance, and in
 7313 some cases, survival rates passing the dams. Additional information on existing conditions for
 7314 fish regarding Columbia River System operations and configurations is provided in NMFS
 7315 biological opinions (NMFS 2008a, 2010a, 2014a, 2019).

7316 Multiple factors have contributed to the historical decline and current status of salmon and
 7317 steelhead. The construction and operations of the Columbia River System are among the many
 7318 factors that have adversely affected these species. The adverse impact of past Columbia River
 7319 System operations has been reduced over time, and multiple mitigation actions have improved
 7320 habitat, hatchery operations, and predator management, thus increasing survival rates of
 7321 individuals in these ESUs, reducing extinction risk, and thereby contributing to improvements in
 7322 the likelihood of recovery.

7323 As adults migrate upstream and juveniles outmigrate, they negotiate up to eight CRS project
 7324 dams, as well as other non-Federal facilities. Factors such as migration delays, fallback,
 7325 encounters with powerhouse facilities, TDG, and water temperatures can all affect the survival
 7326 of anadromous fish.

7327 Metrics used to track these factors include the following:

- | | |
|-----------------------------------|-----------------------------------|
| 7328 • Juvenile travel time | 7331 • Powerhouse encounters |
| 7329 • Juvenile in-river survival | 7332 • Water particle travel time |
| 7330 • Dam passage survival | 7333 • Mortality from GBT |

7334 For some species, information is available to track population level metrics such as adult
7335 abundance (returning adults to a given population), and smolt-to-adult return ratios.

7336 As a group, salmon and steelhead are diverse in their biology, exhibiting a range of life history
7337 and reproductive strategies. Terms that are used in this EIS to describe each species include
7338 descriptors of the migratory patterns of salmon and steelhead and the reproductive types.
7339 Reproductively, salmon and steelhead tend to reproduce once before dying (semelparous), but
7340 some steelhead and other fish can reproduce multiple times (iteroparous).

7341 Anadromous fish hatch from eggs in freshwater, then migrate to the ocean while undergoing
7342 the physiological process of smoltification to grow and mature, and then return to freshwater
7343 as adults to spawn. Non-anadromous fish remain in freshwater throughout their life cycle.
7344 Pacific salmon and steelhead are largely anadromous, although there are non-anadromous
7345 forms (e.g., non-anadromous sockeye are called kokanee, and non-anadromous steelhead are
7346 called rainbow or redband trout).

7347 The terms ESU and DPS comprise one or more populations as a “species” under the ESA. A
7348 population of fish is a group of the same biological species that spawns in a particular lake or
7349 stream (or portion thereof) at a particular season and which, to a substantial degree, does not
7350 interbreed with fish from any other group spawning in a different place or in the same place at
7351 a different season (McElhany et al. 2000). The ESA terms ESU and DPS comprise one or more
7352 populations, as the key feature of an ESU or DPS is reproductive isolation from other groups in
7353 that same species.

7354 Juvenile salmon and steelhead originating above Bonneville Dam migrate downstream through
7355 as many as eight Columbia River System projects, and the same is true for adult salmon and
7356 steelhead returning to spawning grounds in the opposite direction. Migration habitat features
7357 important to salmon and steelhead as they migrate through the Columbia River and lower
7358 Snake River reaches include water quality, water temperature, water velocity, passage survival,
7359 adult fallback (i.e., deviation from upstream migration to move back downstream through dams
7360 already ascended), and factors that may influence delayed mortality.

7361 **Chinook Salmon**

7362 Chinook salmon are the largest of the Pacific salmon and are known by many names, most
7363 commonly king salmon, or Chinook salmon. Chinook salmon have an anadromous life history
7364 (although non-anadromous males and landlocked populations do occur) and are semelparous.
7365 Age at maturity is highly variable among populations, but most Chinook salmon on the West
7366 Coast spawn at 3, 4, or 5 years of age. Chinook salmon are classified into two life history types:
7367 stream-type and ocean-type. These life history types have several ecological differences, but
7368 the most basic difference is how long the juveniles spend in the freshwater habitat prior to
7369 migrating out to the ocean; stream-type juveniles outmigrate as yearlings, whereas ocean-type
7370 juveniles outmigrate much younger and may spend substantial time in the estuarine
7371 environment below Bonneville Dam before entering the ocean environment. In the Columbia
7372 River Basin, Chinook salmon occurring west of the Cascade Crest tend to be primarily ocean-

7373 type (Myers et al. 1998). Chinook salmon occurring east of the Cascade Crest include both
7374 stream-type and ocean-type races, with the stream-type occurring in the Deschutes, John Day,
7375 Yakima, Wenatchee, Entiat, and Methow Rivers (Myers et al. 1998).

7376 Chinook salmon stocks are often described as seasonal “runs.” In the Columbia River Basin,
7377 there are spring-run, summer-run, and fall-run Chinook salmon stocks. The run refers to the
7378 time of year that the adults return to freshwater to start their spawning migration.

7379 Six Chinook salmon ESUs are within the scope of this EIS (Myers et al. 1998):

- 7380 • Upper Columbia River spring-run (ESA-listed endangered, further discussed in this section)
- 7381 • Snake River spring/summer-run (ESA-listed threatened, further discussed in this section)
- 7382 • Middle Columbia River spring-run (not ESA-listed)
- 7383 • Upper Columbia River summer/fall-run (not ESA-listed)
- 7384 • Snake River fall-run–ESA-listed (ESA-listed threatened, further discussed in this section)
- 7385 • Lower Columbia River–ESA-listed (ESA-listed threatened, further discussed in this section)

7386 **Life Histories: What are the Different Migration Timings of Chinook Salmon?**

7387 **Stream- and ocean-types:** Chinook salmon can follow either stream- or ocean-type freshwater life history strategy.
7388 Stream-type Chinook salmon reside in freshwater for a year or more before migrating to the ocean as larger
7389 juveniles. Ocean-type Chinook salmon migrate to the ocean within their first year after emerging from the gravel.

7390 **Run timing:** Salmon runs are named for the season when the adult fish return to their home estuary.

7391 Spring-run Chinook salmon use the stream-type strategy as juveniles, then spend 1 to 4 years maturing in the
7392 ocean before returning to freshwater as immature fish (also called early or bright fish) from March through May.
7393 They migrate upriver, mature in suitable refuges for several months (March to June), and spawn in late summer
7394 and early fall (August to September).

7395 Fall-run Chinook salmon use the ocean-type strategy as juveniles, then spend 1 to 5 years maturing in the ocean
7396 before returning to freshwater. They enter freshwater at an advanced stage of maturity, move rapidly to their
7397 spawning areas, and spawn within a few days or weeks of freshwater entry (late September to November).

7398 **Tules and upriver brights:** Tules are sexually mature fall-run Chinook salmon and spawn in lower Columbia River
7399 tributaries. Upriver brights are fall-run Chinook salmon upstream of The Dalles Dam.

7400 Upper Columbia River Spring-Run Chinook Salmon

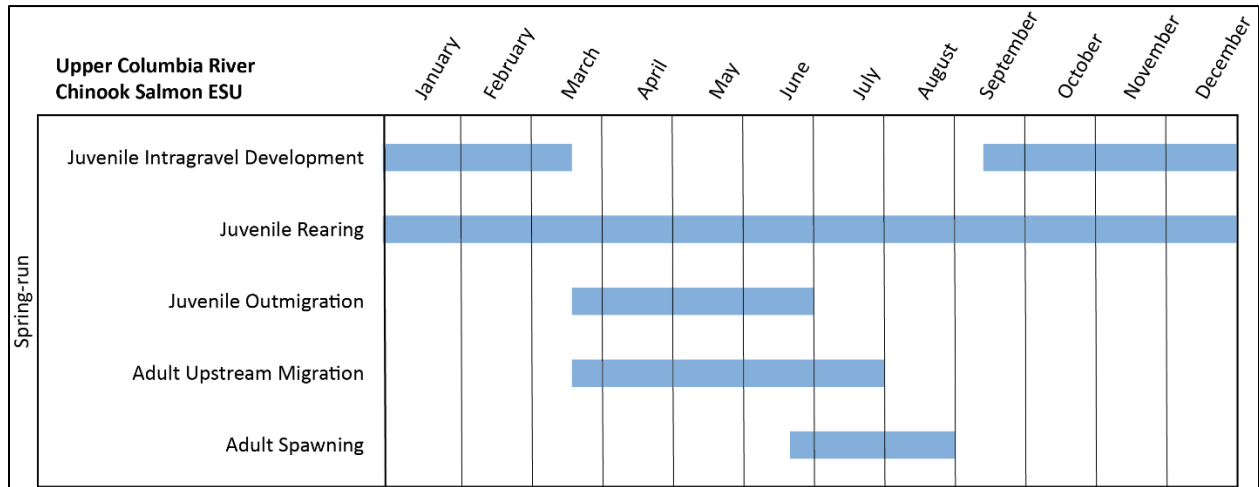
7401 Upper Columbia River spring-run Chinook salmon extant populations include all naturally
7402 spawned populations of Chinook salmon in Columbia River tributaries downstream of Chief
7403 Joseph Dam and upstream of Rock Island Dam, excluding the Okanogan River. This includes
7404 populations spawning in the Wenatchee, Methow, and Entiat Rivers, and the progeny of six
7405 artificial propagation programs. These fish spawn above the confluence of the Snake River and
7406 pass through four Columbia River System projects, including Bonneville, The Dalles, John Day,
7407 and McNary Dams. They also pass up to five non-federal Public Utility District (PUD) owned
7408 mainstem dams (Rocky Reach Dam and Rock Island Dam are owned and operated by Chelan
7409 County PUD while Wanapum Dam and Priest Rapids Dam are owned and operated by Grant
7410 County PUD), and Wells Dam is operated by Douglas County PUD). Annual upper Columbia

7411 River spring-run Chinook salmon returns at Rock Island Dam averaged 3,714 fish between 2010
7412 and 2016 and ranged from 2,167 to 6,090 fish (Oregon Department of Fish and Wildlife [ODFW]
7413 and Washington Department of Fish and Wildlife [WDFW] 2017).

7414 Upper Columbia River spring-run Chinook salmon have unique run timing, both as juveniles and
7415 adults. Juveniles follow a stream-type freshwater cycle, meaning that they outmigrate after 1
7416 year of rearing in freshwater during mid-spring through early summer (NMFS 2018). Returning
7417 adults enter freshwater beginning in early spring, with the peak run occurring in mid-May, and
7418 the fish reach upper Columbia River tributaries from April through July. Some males return to
7419 natal streams after one winter at sea; however, the 4- and 5-year-old adults represent the
7420 majority of the run.

7421 This ESU’s adult return run timing in early spring makes them subject to relatively higher
7422 predation from seals and sea lions (pinnipeds) compared to other salmon species because most
7423 of these pinnipeds arrive in the area downstream of Bonneville Dam in March and April and
7424 leave by early summer.

7425 The adults then hold in tributaries until spawning in the late summer, peaking in mid-late
7426 August (NMFS 2016). After spawning, the adults’ health declines rapidly and they die within a
7427 few days (Figure 3-114).



7428 **Figure 3-114. Freshwater Life Phases for Upper Columbia River Spring-Run Chinook Salmon**
7429 **Evolutionarily Significant Unit**
7430

7431 Source: NMFS (2007, 2018)

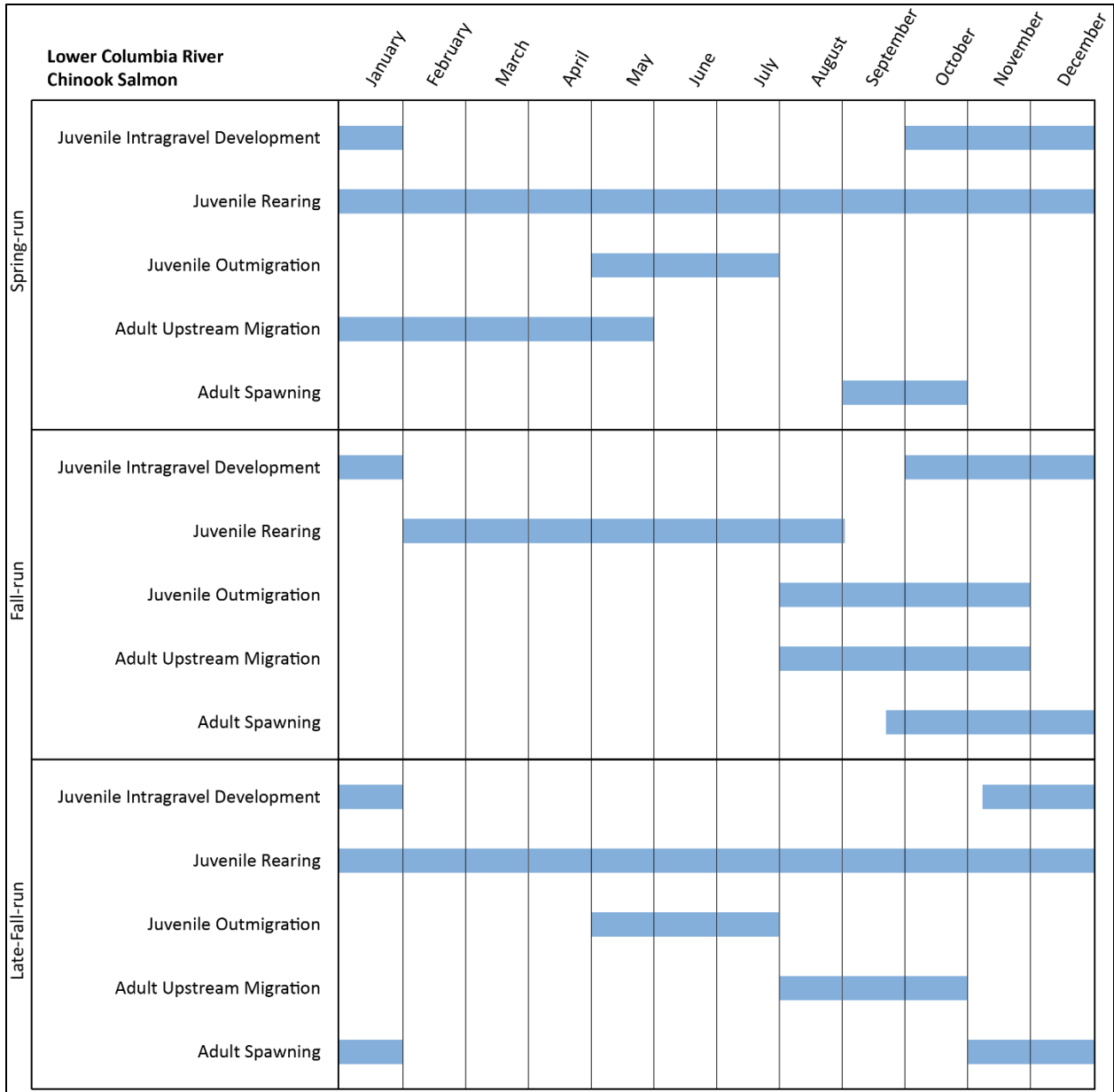
7432 Lower Columbia River Chinook Salmon

7433 The lower Columbia River Chinook salmon ESU includes all naturally spawned populations from
7434 the mouth of the Columbia River upstream to and including the White Salmon River in
7435 Washington and the Hood River in Oregon. This ESU also includes the Willamette River
7436 upstream to Willamette Falls (exclusive of spring-run Chinook salmon in the Clackamas River),
7437 and 15 artificial propagation programs. Bonneville Dam is the only mainstem system facility

7438 within the lower Columbia River Chinook salmon ESU range (NMFS 2013). Lower Columbia
7439 River Chinook salmon might migrate through other non-Columbia River System dams
7440 depending on their spawning locations, rearing, and migratory movements (NMFS 2016).

7441 This ESU follows an ocean-type life history with three distinct patterns based on their return to
7442 freshwater: spring-run Chinook salmon, fall-run Chinook salmon, and late fall-run Chinook
7443 salmon (NMFS 2013). These three components of the Lower Columbia River Chinook Salmon
7444 ESU all have similar ocean distributions but are exposed to different in-river effects because of
7445 migration timing (NMFS 2016).

7446 Lower Columbia River spring-run and late-fall-run juvenile Chinook salmon exhibit a stream-
7447 type maturation that depart in the fall and early winter when they overwinter in larger rivers
7448 before outmigrating the following spring as yearlings. In contrast, lower Columbia River fall-run
7449 Chinook salmon exhibit an ocean-type maturation life history; juveniles emigrate as
7450 subyearlings in late summer or autumn and rely heavily on the Columbia River estuary before
7451 continuing to the ocean (NMFS 2013). Spring-run Chinook salmon enter freshwater from
7452 January through May before spawning from September to October. Fall-run Chinook salmon
7453 enter freshwater from August to October and spawn nearly immediately from October through
7454 December. Late-fall-run adults enter freshwater from August to November and spawn from
7455 November through January (NMFS 2013; Figure 3-115).



7456
 7457 **Figure 3-115. Freshwater Life Phases of Lower Columbia River Chinook Salmon Evolutionarily**
 7458 **Significant Unit**
 7459 Source: NMFS (2013)

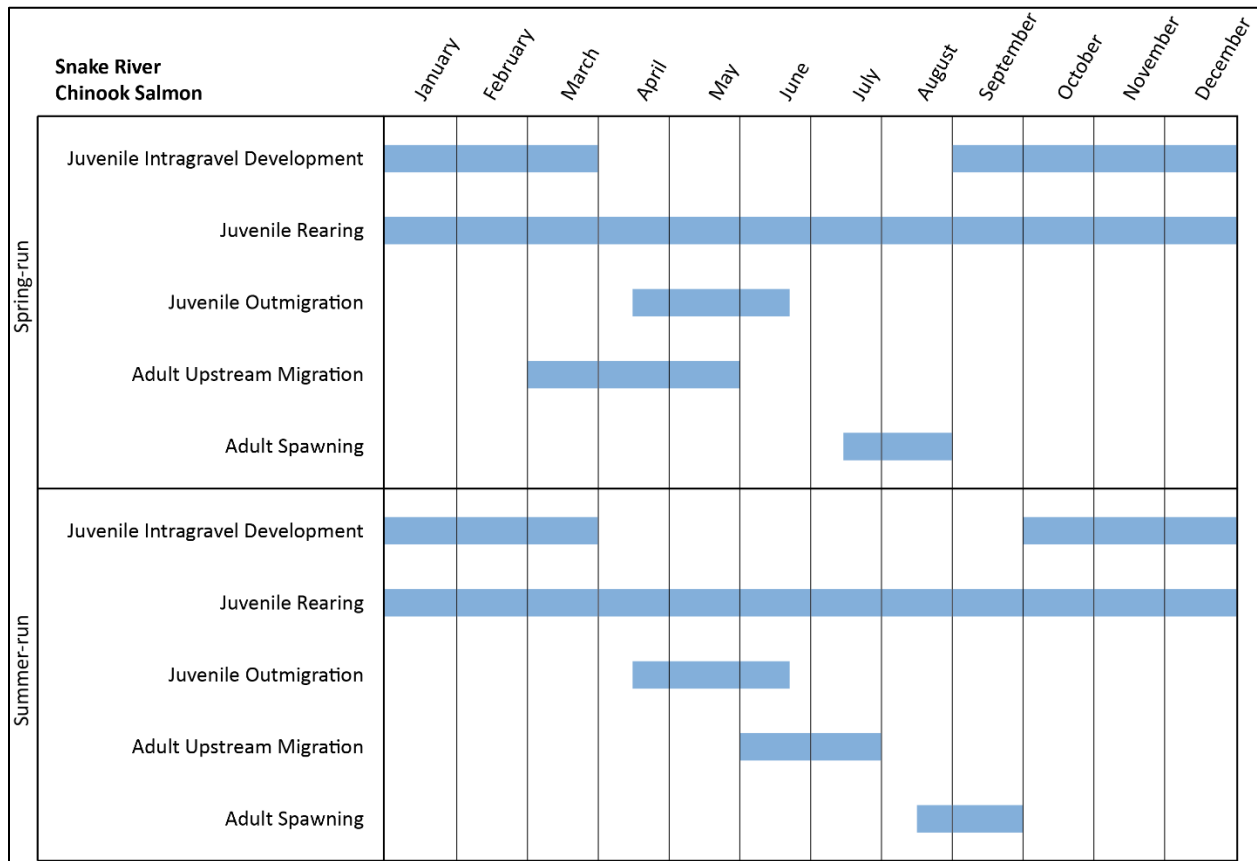
7460 Snake River Spring/Summer Chinook Salmon

7461 The Snake River spring/summer Chinook salmon ESU includes all naturally spawned populations
 7462 of spring/summer Chinook salmon in the mainstem Snake River and the Tucannon River,
 7463 Grande Ronde River, Imnaha River, and Salmon River subbasins (NMFS 2016e), and the progeny
 7464 of 15 artificial production programs.

7465 Two distinct forms are recognized for Snake River Chinook salmon: the spring-run and the
 7466 summer-run; these are distinguished when adult Chinook salmon move through the estuary

7467 and ascend Bonneville Dam in their spawning migration (Figure 3-116). Both spring-run and
 7468 summer-run Chinook salmon display a stream-maturing life history meaning adults enter
 7469 freshwater sexually immature and require a few months in rivers and tributaries to mature
 7470 prior to spawning (NMFS 2017a). Spring-run Chinook salmon enter freshwater primarily from
 7471 March through May and migrate to spawning reaches, then spawn in mid- to late August with
 7472 some spawning extending into early September. Summer-run Chinook salmon enter freshwater
 7473 primarily from June to July and wait to migrate to spawning areas until late summer. Some
 7474 adults from both runs might hold in deep pools before completing their spawning migration.

7475 Snake River Chinook salmon juveniles (both spring-run and summer-run) migrate to the ocean
 7476 from mid-April through early June, with peak migration in mid-May (NMFS 2017a). Spring- and
 7477 summer-run Chinook salmon juveniles have limited variability for rearing in their natal streams,
 7478 but higher variability for the marine life stage, typically between 1 to 3 years.



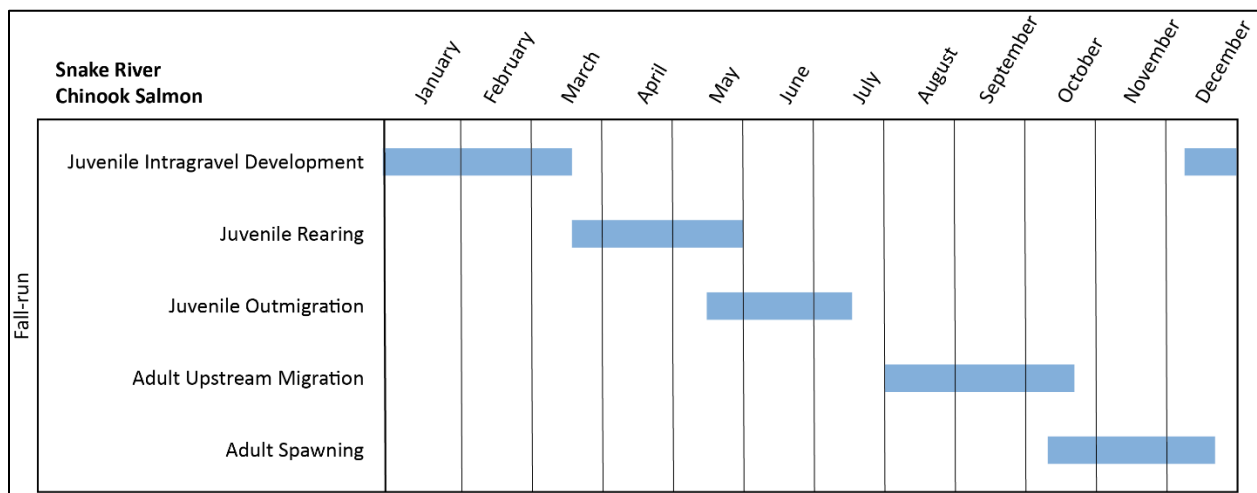
7479 **Figure 3-116. Freshwater Life Phases of Snake River Spring/Summer-Run Chinook Salmon**
 7480 **Evolutionarily Significant Unit**
 7481

7482 Source: NMFS (2017)

7483 Snake River Fall Chinook Salmon

7484 The Snake River fall-run Chinook salmon spawns in the mainstem of the Snake River, Clearwater
 7485 River, and major tributaries.

7486 Snake River fall-run Chinook salmon follow an ocean-type life history; however, some fish in
7487 this ESU delay seaward migration and enter the ocean as yearlings and are referred to as having
7488 a reservoir-type life history (Connor et al. 2005). The majority of Snake River fall-run Chinook
7489 salmon juveniles of wild and hatchery origin migrate to the ocean before mid-summer as
7490 subyearlings, and some wild-origin fall Chinook salmon outmigrate in late summer including
7491 September (Figure 3-117). An exception are the Snake River fall-run Chinook salmon that
7492 migrate as yearlings and primarily originate from the Clearwater River basin (NMFS 2017).
7493 Water temperature influences the rate of development and life history of Snake River fall-run
7494 Chinook salmon, particularly for juveniles. Adult Snake River fall-run Chinook salmon enter the
7495 Columbia River from early August to September and reach the Snake River between mid-August
7496 and mid-October. Adults then spawn in the Snake River and tributaries through early
7497 December.



7498 **Figure 3-117. Freshwater Life Phases of Snake River Fall-Run Chinook Salmon**
7499
7500 Source: NMFS (2017)

7501 **Sockeye Salmon**

7502 Sockeye salmon are also called blueback and red salmon. The Columbia River Basin is the
7503 southern extent of the species on the West Coast (Gustafson et al. 1997). Sockeye salmon have
7504 anadromous and non-anadromous life history types; non-anadromous sockeye salmon, known
7505 as kokanee, are addressed in the Resident Fish sections of this EIS. There are three anadromous
7506 forms of sockeye salmon: lake-type, river-type, and sea-type (Gustafson et al. 1997). Sockeye
7507 salmon in the Columbia River Basin are lake-type and spawn in either inlet or outlet streams of
7508 lakes or in lakes themselves. Juveniles rear in the lake for 1 to 3 years before smolting and
7509 migrating to the marine environment for 1 to 4 years; adults generally return to their natal lake
7510 system to spawn. Effects to kokanee populations will be discussed in the resident sections
7511 where they occur.

7512 Three Sockeye Salmon ESUs are within the scope of this EIS:

- 7513 • Snake River (ESA-listed, further discussed in this section)

- 7514 • Okanagan River (not ESA-listed)
- 7515 • Lake Wenatchee (not ESA-listed)

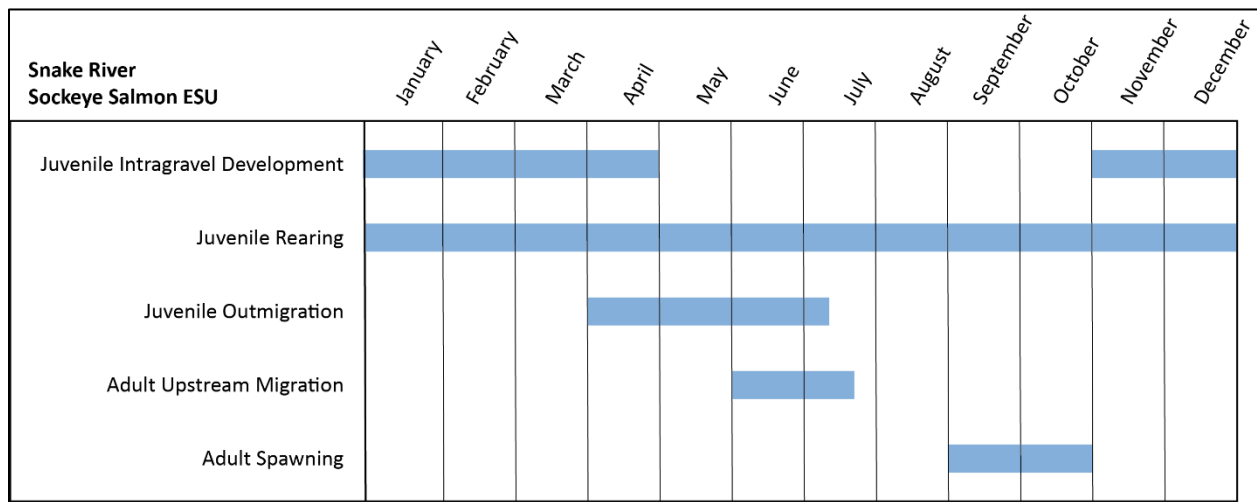
7516 Snake River Sockeye Salmon

7517 Snake River sockeye salmon are ESA-listed as endangered. This ESU includes naturally spawned
7518 anadromous and residual sockeye salmon originating from the Snake River Basin, primarily
7519 from Redfish Lake, and also sockeye salmon from an artificial propagation program, Redfish
7520 Lake Captive Broodstock Program. Snake River sockeye salmon migrate through eight Columbia
7521 River System projects on their migratory route to and from the Pacific Ocean (NMFS 2009).

7522 Adult Snake River sockeye salmon enter the Columbia River primarily from June through July
7523 when they migrate directly to suitable lake habitat to spawn. Adult sockeye salmon will spawn
7524 from September through October in the lakeshore gravels (ODFW and WDFW 2017).

7525 Anadromous juveniles will rear in their natal lakes for one to three years before outmigrating.
7526 Anadromous Snake River sockeye salmon juveniles migrate to the ocean from April through
7527 early July, with peak migration typically occurring in mid-April to early May (Figure 3-118)
7528 (NMFS 2015).

7529 Resident sockeye salmon remain in freshwater to mature and reproduce (often referred to as
7530 kokanee).



7531 **Figure 3-118. Freshwater Life Phases of Snake River Sockeye Salmon Evolutionarily Significant**
7532 **Unit**

7533 Source: NMFS (2015)

7535 **Coho Salmon**

7536 Coho salmon are also commonly known as silver salmon. Coho are anadromous, with a fixed
7537 life history, and semelparous. Coho salmon south of Alaska are three years old at maturity,
7538 spending half of that time in the freshwater environment prior to smolting (Weitkamp et al.

7539 1995). Historically, coho salmon distribution extended to the upper Columbia River and the
7540 Snake River Basin (Weitkamp et al. 1995).

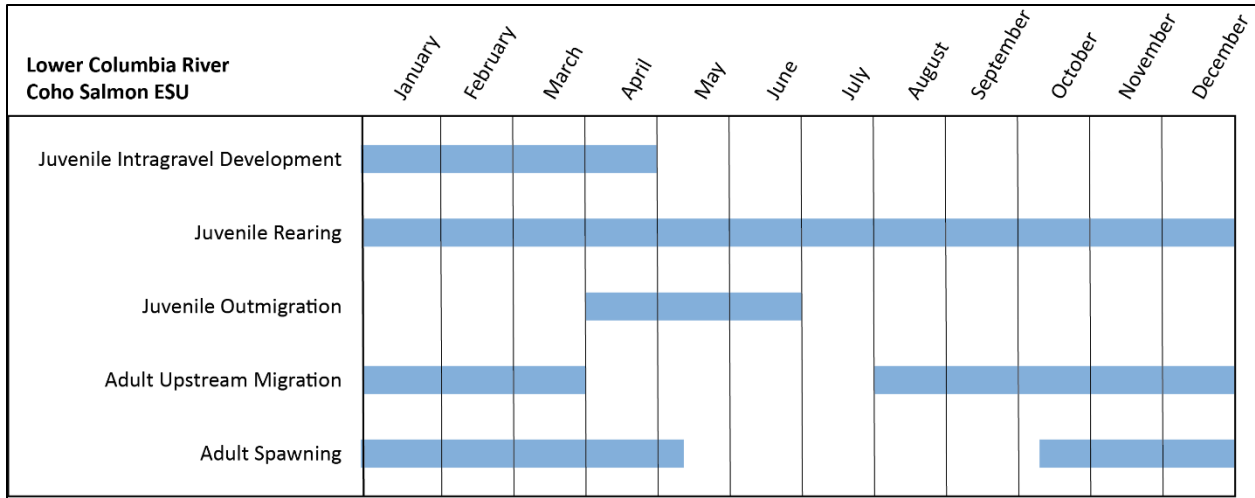
7541 Lower Columbia River coho salmon are the only ESA-listed population of coho salmon in the
7542 Columbia River Basin; coho salmon found upstream of The Dalles Dam are not ESA-listed.
7543 Although coho salmon in the upper Columbia River, Snake River and their tributaries were
7544 extirpated, reintroduction programs conducted in the Clearwater, Wenatchee, Methow, and
7545 Yakima River Basins are resulting in coho salmon returning to those rivers.

7546 Lower Columbia River Coho Salmon

7547 Bonneville Dam is the only mainstem system facility within the lower Columbia River coho
7548 salmon ESU range (NMFS 2013). These fish extend up the Columbia River as far as the Hood
7549 River basin and may encounter other dams in tributaries to the Columbia River depending on
7550 their spawning locations, rearing, and migratory movements within the basin (NMFS 2016a).

7551 Two categories are used regarding lower Columbia River coho salmon based on their return to
7552 freshwater: early-return (Type S) and late-return (Type N). While there is some overlap
7553 between these populations, Type S coho salmon generally move south of the Columbia River
7554 mouth once smolts outmigrate, and Type N coho salmon smolts and adults generally move
7555 north of the Columbia River mouth (NMFS 2013).

7556 Type S and Type N coho salmon juveniles rear in freshwater for one to four years in pool habitat
7557 and quiet backwaters, side channels, and small creeks. Juveniles typically outmigrate as smolts
7558 from April to June, typically during their second year (Figure 3-119) (NMFS 2013). Lower
7559 Columbia River coho salmon exhibit a stream-type maturation, indicating they arrive in the
7560 Columbia River and require several months within freshwater to reach sexual maturity before
7561 spawning. Type S coho salmon adults enter freshwater in mid-August before spawning from
7562 mid-October to early November. Type N coho salmon adults enter freshwater from late
7563 September to December and spawn nearly immediately from November through January
7564 (NMFS 2013).



7565
 7566 **Figure 3-119. Freshwater Life Phases of Lower Columbia River Coho Salmon Evolutionarily**
 7567 **Significant Unit**
 7568 Source: NMFS (2013)

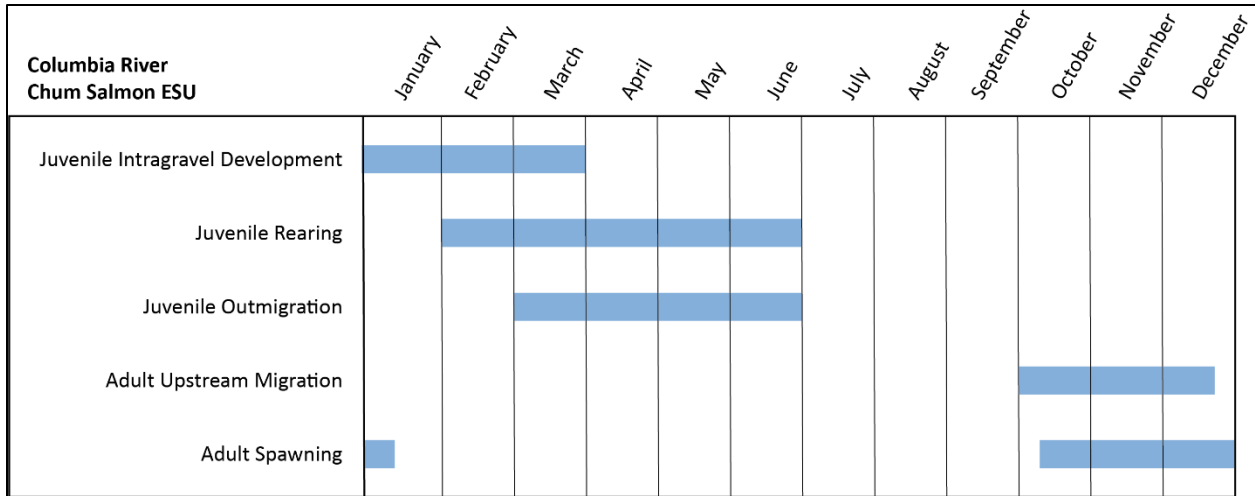
7569 ***Chum Salmon***

7570 Columbia River Chum Salmon

7571 Although distributed in locations above the dam historically, Bonneville Dam is the only
 7572 mainstem hydropower facility within the mainstem Columbia River that chum salmon may be
 7573 expected to pass (NMFS 2013). Though chum salmon are strong swimmers, they rarely pass
 7574 river blockages and waterfalls, and spawn almost exclusively downstream of Bonneville Dam
 7575 (NMFS 2016a).

7576 Columbia River chum salmon spawn and incubate redds in the mainstem itself, and spawning is
 7577 restricted primarily to tributary and mainstem areas downstream of Bonneville Dam. The
 7578 species requires clean gravel for spawning and their spawning sites are typically associated with
 7579 areas of upwelling water. Near Ives Island (downstream of Bonneville Dam), chum spawn in
 7580 shallow areas where it appears river water is warmed by its transit through the gravel (Geist et
 7581 al. 2002). Chum salmon also spawn in the tailrace of Bonneville Dam.

7582 Columbia River chum salmon juveniles rear in freshwater very briefly after emerging from
 7583 gravel. Juveniles typically outmigrate to the Columbia River estuary as subyearlings from March
 7584 to June, where they spend several weeks to months before continuing to the ocean (NMFS
 7585 2013) (Figure 3-120). Columbia River chum salmon are primarily fall-run fish with very few
 7586 exhibiting a summer-run life history. Adults arrive in freshwater from October through
 7587 November after 2 to 6 years and spawn from November through December (NMFS 2013).
 7588 During chum salmon spawning and egg incubation, the water surface elevation of the
 7589 Bonneville tailrace is controlled to protect chum salmon redds (NMFS 2016b).



7590
7591 **Figure 3-120. Freshwater Life Phases of Columbia River Chum Salmon Evolutionarily**
7592 **Significant Unit**

7593 Source: NMFS (2013)

7594 **Steelhead**

7595 The name *steelhead* is used in this EIS to refer to anadromous populations of the biological
7596 species *Oncorhynchus mykiss*. Steelhead are anadromous, although individual fish may
7597 residualize and remain non-anadromous and have the capacity for iteroparity. Iteroparous
7598 steelhead are predominately female (Busby et al. 1996); males tend to be semelparous.
7599 Juvenile steelhead can spend between one and seven years in freshwater prior to smolting, and
7600 then spend up to three years in the ocean before their first spawning migration (Busby et al.
7601 1996). Most steelhead in the Columbia River Basin spend two years in freshwater and two years
7602 in the ocean; some populations east of the Cascade Crest have only one ocean year (Busby et
7603 al. 1996). Steelhead have two reproductive ecotypes: ocean-maturing and stream-maturing
7604 (Busby et al. 1996). On the West Coast, these correspond to winter steelhead and summer
7605 steelhead, respectively. Ocean-maturing winter steelhead enter freshwater in a sexually mature
7606 condition and spawn shortly thereafter; stream-maturing summer steelhead enter freshwater
7607 in a sexually immature condition and can spend several months in freshwater prior to spawning
7608 (Busby et al. 1996). Both of these ecotypes occur in the Columbia River Basin.

7609 Steelhead, and their non-anadromous kin, have two major genetic groupings that are different
7610 enough to be considered subspecies by some authors: coastal steelhead and rainbow trout (*O.*
7611 *m. irideus*), and inland steelhead and redband trout (*O. m. gairdneri*). Both subspecies occur in
7612 the Columbia River Basin. The coastal grouping occurs as far upstream as the Hood River in
7613 Oregon and the Wind River in Washington. The inland grouping occurs upstream of those
7614 rivers. Coastal steelhead can be winter or summer steelhead; inland steelhead are almost
7615 exclusively summer steelhead (i.e., stream-maturing) (Busby et al. 1996).

7616 After spawning, some adult steelhead (up to 50 percent) do not die and, instead, attempt to
7617 return to the ocean, which requires these fish to migrate downstream through the dams as
7618 adults. These fish are referred to as kelts and migrate downstream in April and May during the

7619 spring freshet, similar to salmon smolts. Adult fish passage through the dams is difficult and
7620 dependent on flow, so passage survival is low during low-flow years.

7621 Four steelhead DPSs are within the scope of this EIS:

- 7622 • Upper Columbia River (ESA-listed threatened, further discussed in this section)
- 7623 • Middle Columbia River (ESA-listed threatened, further discussed in this section)
- 7624 • Lower Columbia River (ESA-listed threatened, further discussed in this section)
- 7625 • Snake River Basin (ESA-listed threatened, further discussed in this section)

7626 **What Are the Terms Used to Describe Steelhead?**

7627 Steelhead are one of three salmonid species in the Columbia River Basin (besides coastal cutthroat trout and bull
7628 trout) that may spawn multiple times.

7629 **Overwintering:** Winter runs of steelhead migrate upstream between November and April, and spawn quickly after
7630 arrival at spawning grounds. Summer run steelhead migrate from early summer to late fall to use "overwintering"
7631 habitat in reservoirs or low in tributaries before spawning in higher elevation habitat months later in early spring.

7632 **Overshoots:** Some migrating adult steelhead may swim past their natal home stream as noted in passive
7633 integrated transponder (PIT) tag detections at dams upstream from the known source stream; these steelhead are
7634 referred to as "overshoots."

7635 **Kelts:** After spawning, as many as 50 percent of steelhead can live to spawn again. They migrate downstream to
7636 marine waters to feed as post-spawn adults. These downstream migrating adult steelhead are called "kelts."

7637 **What is Unique about Steelhead Life History?**

7638 The life history pattern of steelhead in the upper Columbia River Basin is complex. Adults return to the Columbia
7639 River in the late summer and early fall. Unlike fall Chinook, most steelhead do not move upstream quickly to
7640 tributary spawning streams. A portion of the returning run overwinters in the mainstem reservoirs, passing over
7641 the upper Columbia River dams in April and May of the following year. Spawning occurs in late spring of the
7642 calendar year following entry into the river. Currently, the majority of adult steelhead passing Lower Granite Dam
7643 are hatchery origin fish. The effectiveness of hatchery fish spawning in the wild compared to naturally produced
7644 spawners is unknown at this time and may be a major factor in reducing steelhead productivity.

7645 Juvenile steelhead typically spend one to three years rearing in freshwater before migrating to the ocean but can
7646 spend as many as seven years in freshwater before migrating. Most adult steelhead return to the upper Columbia
7647 River after one or two years at sea. Steelhead in the upper Columbia River have a relatively high fecundity,
7648 averaging between 5,300 and 6,000 eggs.

7649 Steelhead can lose the ability to smolt in tributaries and never migrate to sea, thereby becoming resident rainbow
7650 trout. Conversely, progeny of resident rainbow trout can migrate to the sea and thereby become steelhead.

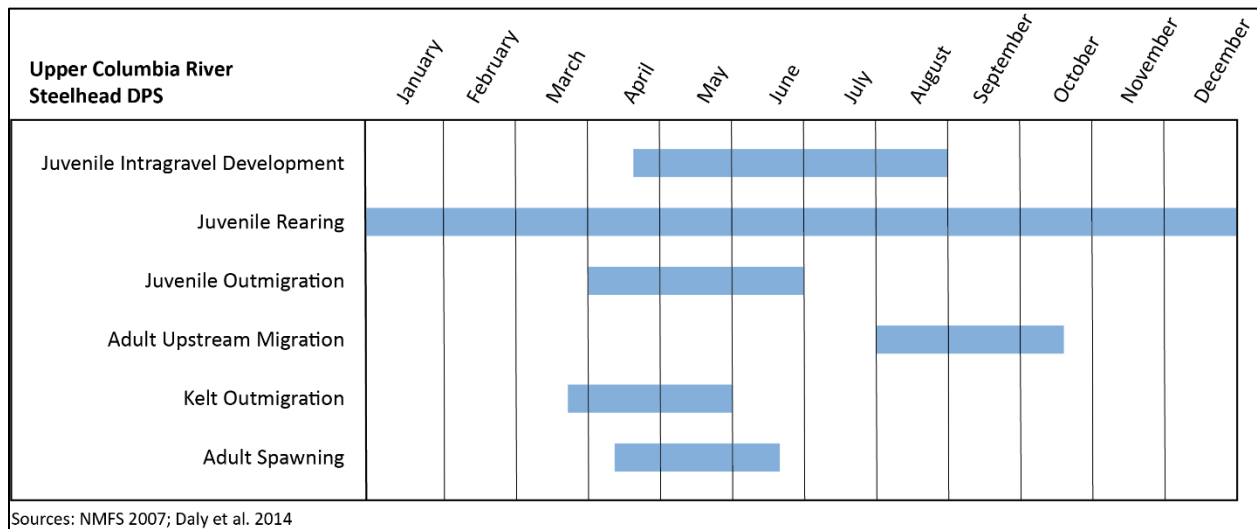
7651 Despite the apparent reproductive exchange between resident and anadromous *O. mykiss*, the two life forms
7652 remain separated physically, physiologically, ecologically, and behaviorally (70 FR 67130). Given this separation,
7653 NMFS (70 FR 67130) has proposed that the anadromous steelhead populations are discrete from the resident
7654 rainbow trout populations.

7655 Upper Columbia River Steelhead

7656 Upper Columbia River steelhead may migrate through as many as nine dams including four
7657 Columbia River System projects within the Columbia River (Bonneville, The Dalles, John Day,
7658 and McNary Dams) on their migratory route to and from the Pacific Ocean, dependent on

7659 where the species has spawned (NMFS 2009). Overshoot steelhead may pass through Ice
7660 Harbor and Lower Monumental Dams in the Snake River, needing to then pass downstream out
7661 of the Snake River to continue their migration up the Columbia River. Chief Joseph Dam has no
7662 upstream fish passage and represents the end of the anadromous zone.

7663 Upper Columbia River steelhead juveniles migrate to the ocean from mid-April through early
7664 June, with peak migration typically occurring in mid-May (Daly et al. 2014). Juveniles rear in the
7665 Columbia River for one to three years before outmigrating (Figure 3-121). Adult upper Columbia
7666 River steelhead enter freshwater from late summer to early fall and overwinter in larger rivers,
7667 such as the Columbia River, before migrating to tributaries to spawn. Adult steelhead then
7668 spawn from the following April through mid-June (NMFS 2007).



7669
7670 **Figure 3-121. Freshwater Life Phases of Upper Columbia River Steelhead Distinct Population**
7671 **Segment**

7672 Source: NMFS (2007); Daly et al. (2014)

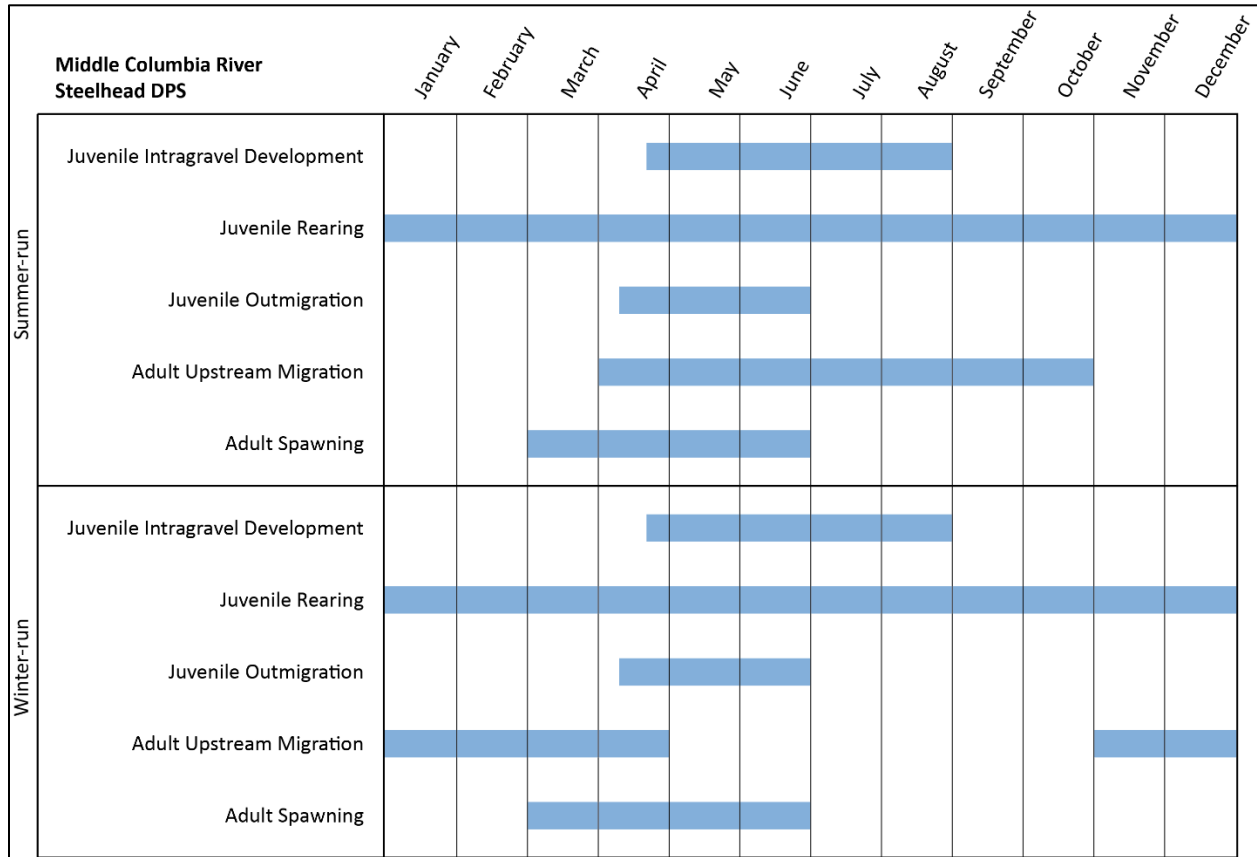
7673 Middle Columbia River Steelhead Distinct Population Segment

7674 Middle Columbia River steelhead may migrate through four projects within the Columbia River
7675 (Bonneville, The Dalles, John Day, and McNary Dams) on their migratory route to and from the
7676 Pacific Ocean. These fish may pass additional dams outside the project area depending on the
7677 population (NMFS 2009).

7678 Two distinct forms are recognized for the Middle Columbia River Steelhead DPS: the stream-
7679 maturing type (summer-run steelhead) that require several months in freshwater prior to
7680 spawning and the ocean-maturing type (winter-run steelhead) that enter freshwater and spawn
7681 shortly after winter entry (Figure 3-122). Most middle Columbia River steelhead are summer-
7682 run steelhead (ODFW and WDFW 2017).

7683 Columbia River steelhead juveniles (both summer-run and winter-run) migrate to the ocean
7684 from mid-April through early June with peak migration typically occurring in mid-May (Daly et

7685 al. 2014). Juvenile winter steelhead outmigrate March through June (ODFW and WDFW 2017).
 7686 Summer steelhead enter freshwater from April through October and overwinter in larger rivers,
 7687 such as the Columbia River. Winter steelhead enter freshwater from November to April and
 7688 migrate to spawning areas immediately. Both summer and winter steelhead spawn from March
 7689 through June (ODFW and WDFW 2017).



7690
 7691 **Figure 3-122. Freshwater Life Phases of Middle Columbia River Steelhead Distinct Population**
 7692 **Segment**

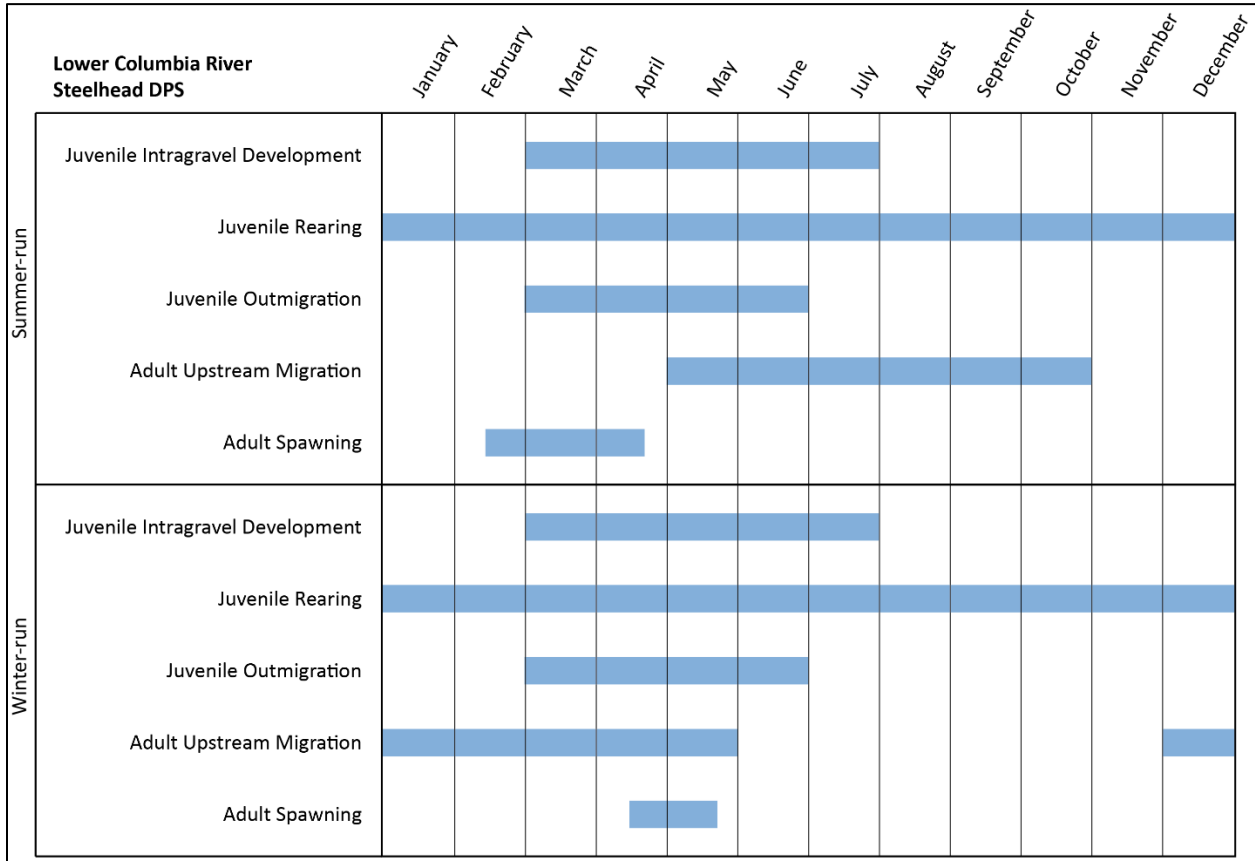
7693 Source: ODFW (2010); Daly et al. (2014); DOE (2015); Keefer et al. (2015); ODFW and WDFW (2017)

7694 Lower Columbia River Steelhead Distinct Population Segment

7695 Two distinct forms are recognized for the Lower Columbia River Steelhead population: the
 7696 summer-run steelhead that require several months in freshwater prior to spawning, and
 7697 winter-run steelhead that enter freshwater and spawn shortly after winter entry (Figure 3-123).
 7698 The majority of lower Columbia River steelhead are summer-run steelhead (NMFS 2016). Only
 7699 Bonneville dam is encountered by this population of steelhead.

7700 Lower Columbia River steelhead summer-run and winter-run juveniles rear for 1 to 4 years
 7701 before outmigrating as smolts from March to June (NMFS 2013) (Figure 3-124). Adult summer-
 7702 run steelhead enter freshwater from May to October and require several months to mature
 7703 prior to spawning from late February to early April. Winter-run steelhead enter freshwater from

7704 December to May already sexually mature and spawn in the spring between April and May
 7705 (NMFS 2013).



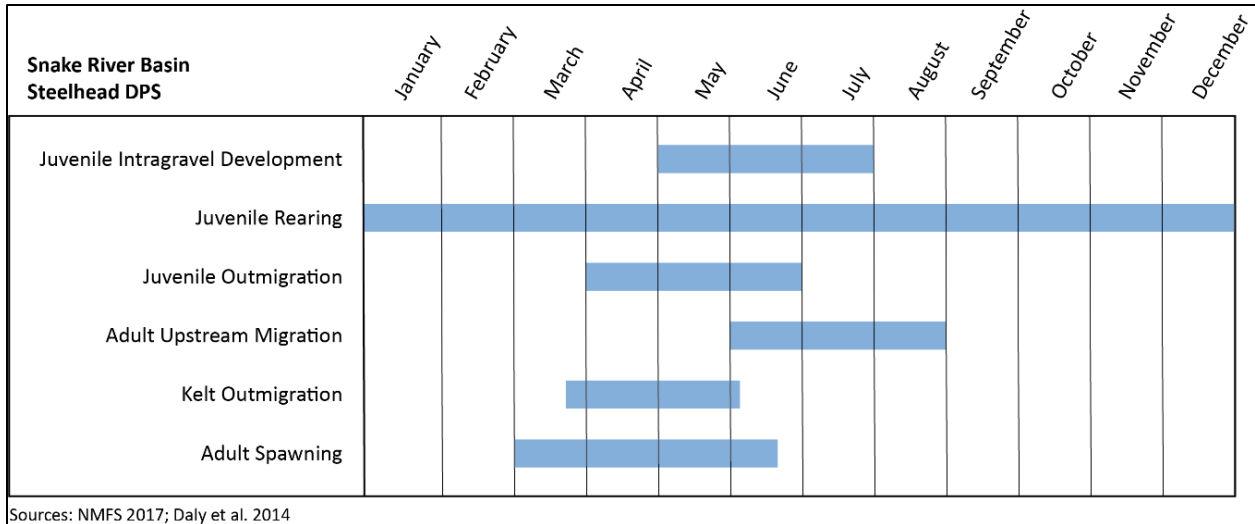
7706 **Figure 3-123. Freshwater Life Phases of Lower Columbia River Steelhead Distinct Population**
 7707 **Segment**
 7708

7709 Source: NMFS (2013)

7710 Snake River Steelhead

7711 Snake River steelhead may migrate through as many as eight Columbia River System projects
 7712 within the Columbia and Snake Rivers on their migratory route to and from the Pacific Ocean
 7713 dependent on where the species has spawned (NMFS 2009). Columbia River System projects
 7714 that Snake River Basin steelhead migrate through include the four lower Columbia River dams
 7715 and four lower Snake River dams.

7716 Snake River Basin steelhead juveniles migrate to the ocean from April to June with peak
 7717 migration typically occurring in mid-May (Figure 3-124) (NMFS 2017). Steelhead have high
 7718 variability in the duration juveniles rear in their natal streams; typically, juveniles will smolt
 7719 between 2 and 3 years. Snake River Basin steelhead are primarily considered summer-run as
 7720 adults enter freshwater from June through August and continue migrating during September
 7721 before overwintering in the mainstem rivers and tributaries throughout their range. The adults
 7722 then migrate to tributaries to spawn between March and early June.



Sources: NMFS 2017; Daly et al. 2014

7723
 7724 **Figure 3-124. Freshwater Life Phases of Snake River Basin Steelhead Distinct Population**
 7725 **Segment**

7726 Source: Daly et al. (2014); NMFS (2017)

7727 **Other Endangered Species Act–Listed Anadromous Fish**

7728 Other ESA-listed anadromous fish beyond salmon and steelhead species are also located within
 7729 the study area.

7730 ***Eulachon***

7731 *Eulachon (Thaleichthys pacificus)*, also known as Pacific smelt, are an anadromous smelt,
 7732 endemic to the northeastern Pacific Ocean. They spawn in rivers from northern California to
 7733 southwestern Alaska (NMFS 2017). *Eulachon* are rich in calories and are important to marine
 7734 and freshwater food webs, commercial and recreational fishers, and indigenous people (WDFW
 7735 and ODFW 2001). *Eulachon* are prey for marine mammals, salmon, sturgeon, and birds. In
 7736 marine waters, *eulachon* are important in the food chain as prey of salmon and steelhead
 7737 (Gustafson et al. 2010). Based on genetic information and spawning site fidelity, NMFS has
 7738 determined that *eulachon* along the West Coast contains two DPSs. Only the Southern DPS of
 7739 *eulachon* occur in the action area.

7740 **Southern Eulachon Distinct Population Segment**

7741 The southern *eulachon* DPS includes fish that spawn in rivers south of the Nass River in British
 7742 Columbia to, and including the Mad River in California (Gustafson et al. 2010). Tributaries of the
 7743 Columbia River that have supported *eulachon* runs in the past include the Grays, Elochoman,
 7744 Cowlitz, Kalama, and Lewis Rivers in Washington and the Sandy River in Oregon (Gustafson et
 7745 al. 2010). In the Columbia River, *eulachon* spawning runs occur annually on the mainstem lower
 7746 Columbia and Cowlitz Rivers; these areas are downstream from Bonneville Dam, and the
 7747 historical range included areas just upstream from the dam (Fish Commission of Oregon 1953).

7748 Critical habitat for this DPS was defined on October 20, 2011, and includes the physical and
7749 biological features essential for conservation of eulachon in freshwater and estuarine areas
7750 downstream of Bonneville Dam (76 FR 65324). As described in its critical habitat designation,
7751 important eulachon habitat features can be summarized as (1) freshwater spawning and
7752 incubation sites with supportive water flow, quality, and temperature conditions; (2)
7753 unobstructed freshwater and estuarine migration corridors; and (3) nearshore and offshore
7754 marine foraging habitat with supportive water quality and available prey (76 FR 65324). The
7755 largest spawning run of eulachon uses the lower Columbia River mainstem and tributaries.

7756 The timing and usage of spawning habitats has considerable year-to-year variation and is
7757 dependent on site-specific environmental factors in the lower Columbia River. Eulachon
7758 migration beyond the Lewis River (RM 87) is limited to years of very high abundance and
7759 passage to Bonneville Dam (RM 146) is rare (WDFW 2009). Historical investigations from the
7760 1950s indicate adult eulachon occasionally migrated to Bonneville Dam, with some fish
7761 successfully passing the dam through the navigation locks to spawn as far upstream as Hood
7762 River (Fish Commission of Oregon 1953; Smith and Saalfeld 1955).

7763 Eulachon eggs are released and fertilized in the water column in a broadcast spawning strategy
7764 (Cowlitz Indian Tribe 2014). Fertile eggs in the water column slowly sink as they drift
7765 downstream and eventually adhere to river substrates, typically in areas of pea-sized gravel and
7766 coarse sand (WDFW and ODFW 2001). Fertilized eggs typically require 30 to 40 days for larval
7767 development before hatching. After this incubation period, the eggs hatch and the larvae drift
7768 immediately out to the estuary, usually within hours to days (Cowlitz Indian Tribe 2014).
7769 Because the larvae are rapidly flushed out to the ocean by river currents with minimal time in
7770 freshwater, it is believed eulachon imprint and home to their native estuary, then select specific
7771 rivers and spawning areas based on environmental conditions at the time of their return (Hay
7772 and McCarter 2000). Adult eulachon typically enter the lower Columbia River from December to
7773 March (ODFW and WDFW 2001; NMFS 2008). A small run of eulachon can occur as early as
7774 mid-November (Cowlitz Indian Tribe 2014). Multiple runs of eulachon may migrate through the
7775 river each year. Peak abundance typically occurs in February and March (NMFS 2008).
7776 Spawning occurs in the lower sections of rivers at temperatures ranging from 4°C to 10°C.
7777 Water temperatures colder than 4°C can slow or stop migration (ODFW and WDFW 2001).
7778 When river temperatures vary above or below normal, eulachon may fail to spawn, delay
7779 spawning, or modify their migratory behavior (NMFS 2017).

7780 **Green Sturgeon**

7781 The green sturgeon (*Acipenser medirostris*) is a marine-oriented and slow-growing anadromous
7782 fish (average length of 50 to 55 inches, or 130 cm) that ranges from Alaska to Mexico. Outside
7783 of their natal system, adult and subadult green sturgeon migrate to the lower Columbia River
7784 estuary for feeding and optimization of growth (NMFS 2009). Within the lower Columbia River
7785 Basin, green sturgeon are common and were observed as far as 140 miles (225 km) upstream in
7786 the Columbia River prior to the construction of Bonneville Dam (Wydoski and Whitney 1979).
7787 Today, they do not move upriver beyond about RM 27 (WDFW 2007). In estuaries, they feed on

7788 shrimp, amphipods, isopods, clams, worms, and an assortment of crabs and fish (Moyle et al.
7789 1995; Dumbauld, Holden, and Langness 2008).

7790 Based on genetic information and spawning site fidelity, NMFS has determined green sturgeon
7791 along the West Coast contain two DPSs: (1) a northern DPS consisting of populations in coastal
7792 watersheds northward and including the Eel River; and (2) a southern DPS consisting of coastal
7793 Central Valley populations south of the Eel River, which is its only known spawning population
7794 in the Sacramento River (68 FR 4433; NMFS 2002). The northern DPS is not listed. Both the
7795 southern and northern DPSs occur in the Columbia River with recent surveys showing more
7796 southern DPS than northern DPS green sturgeon (NMFS 2015).

7797 Southern Green Sturgeon Distinct Population Segment

7798 The southern DPS green sturgeon appear in high concentrations in coastal bays and estuaries
7799 along the west coast of North America during the summer and autumn, particularly in Willapa
7800 Bay, Grays Harbor, and the Columbia River estuary. Recent data indicates the majority of these
7801 fish are either immature or in the early stages of maturation (WDFW and ODFW 2012).

7802 Designated green sturgeon critical habitat includes the Columbia River estuary from the mouth
7803 to RM 46 (74 FR 52300).

7804 Juvenile green sturgeon are not known to use the lower Columbia River estuary (NMFS 2018).
7805 However, in 2011, WDFW and ODFW (2012) found an age-0 (i.e., less than 1 year old) green
7806 sturgeon in the Columbia River downstream of Bonneville Dam. This was the first time an age-0
7807 green sturgeon had been observed in the Columbia River. The specimen was retained and
7808 preserved, and genetic analysis confirmed that the animal is a green sturgeon (NMFS 2015).

7809 Adult green sturgeon congregate in deep water areas of the estuary during the summer and fall
7810 based on tagging and recapture studies and subsequent analyses (ODFW and WDFW 2014).
7811 Peak numbers of green sturgeon occur from July through September (WDFW 2007); during this
7812 period, the Columbia River estuary is believed to have the largest concentration of southern
7813 DPS green sturgeon compared to other estuaries along the West Coast (NMFS 2009).
7814 Commercial gillnet harvest records from 1981 to 2003 provide evidence that green sturgeon
7815 primarily use the lower portions of the Columbia River estuary, with infrequent movement
7816 upstream of RM 27 (WDFW 2007).

7817 **NON-ENDANGERED SPECIES ACT–LISTED ANADROMOUS FISH**

7818 An inventory of the non-ESA-listed anadromous species in the study area appears in Table 3-58.

7819 **Table 3-58. Non-Endangered Species Act-Listed Anadromous Columbia River Basin Species**

Species and ESU or DPS
Upper Columbia River Summer/Fall Chinook ESU (<i>Oncorhynchus tshawytscha</i>)
Middle Columbia Spring Chinook ESU (<i>O. tshawytscha</i>)
Southwest Washington Steelhead DPS (<i>O. mykiss</i>)
Upper Columbia River Sockeye ESU (<i>O. nerka</i>)
Upper Columbia River Coho ESU (<i>O. kisutch</i>)
Snake River Coho ESU (<i>O. kisutch</i>)
Pacific lamprey (<i>Entosphenus tridentatus</i>)

7820 **Salmon and Steelhead**

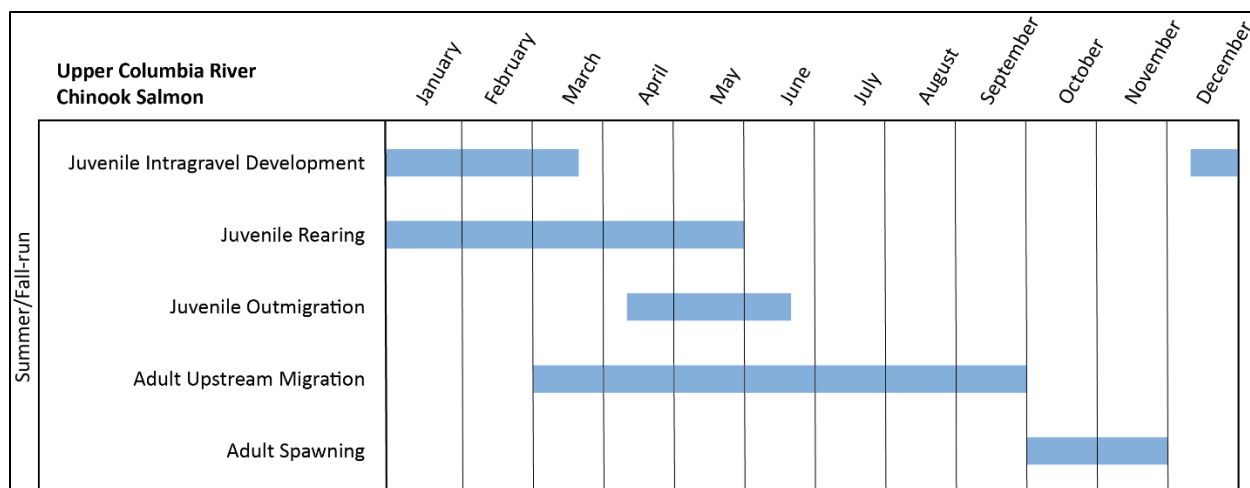
7821 ***Chinook Salmon***

7822 Upper Columbia River Summer/Fall-Run Chinook Salmon

7823 This ESU is not ESA-listed and was considered not warranted for listing (Myers et al. 1998).
7824 Hatchery production is associated with this ESU. The EIS focus for this species is where the
7825 species occurs and migrates through the mainstem of the Columbia and Snake Rivers.

7826 Upper Columbia River summer/fall-run Chinook salmon may migrate through four Columbia
7827 River System projects based on their spawning area location and travel route to the ocean.
7828 These projects include the four lower Columbia dams. The species migrates through several
7829 other dams in the Columbia River and its tributaries, and the species spawns within the
7830 mainstem of the Columbia River and tributaries including the Wenatchee, Entiat, Chelan,
7831 Methow, Okanogan, and Similkameen Rivers.

7832 Summer-run and fall-run Columbia River Chinook salmon have an ocean-type or subyearling life
7833 history, where young fish emerge from redds from late winter through early spring, rear and
7834 grow rapidly, and then migrate seaward before mid-summer (Figure 3-125). In addition, many
7835 upper Columbia River hatchery origin summer Chinook display a yearling life history, where
7836 they grow more slowly and holdover one year and migrate to the ocean the following year.
7837 Summer Chinook salmon enter the Columbia River from late spring (May) through late summer
7838 (August), whereas fall Chinook salmon enter the Columbia River from late summer (early
7839 August) through early November.



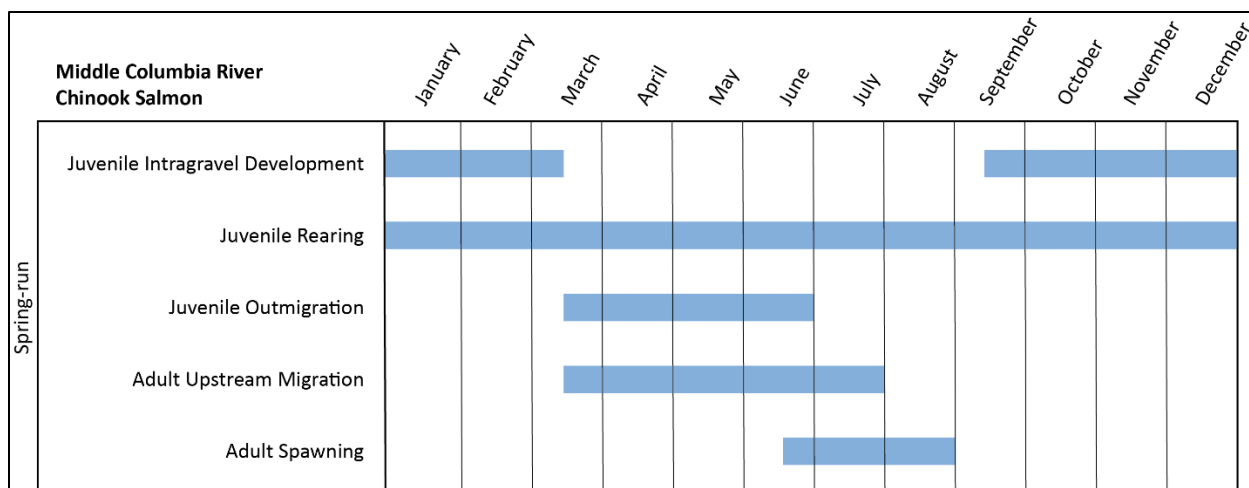
7840
 7841 **Figure 3-125. Freshwater Life Phases of Columbia River Summer/Fall-Run Chinook Salmon**
 7842 Source: WDFW (2006)

7843 Middle Columbia River Spring-Run Chinook Salmon

7844 This ESU is not ESA-listed and was considered not warranted in 1998 (63 FR 11482). The EIS
 7845 focus for this species is where the species occurs and migrates through the mainstem of the
 7846 Columbia River.

7847 Middle Columbia River spring-run Chinook salmon may migrate through four projects within
 7848 the lower Columbia River on their migratory route to and from the Pacific Ocean dependent on
 7849 where the species has spawned.

7850 Middle Columbia River spring-run Chinook salmon juveniles have a similar life history as upper
 7851 Columbia River spring-run Chinook salmon. The fish migrate to the ocean in the spring of their
 7852 second year of life. Juvenile spring-run Chinook salmon outmigrate after one year of rearing,
 7853 mid-spring through early summer (Figure 3-126). Similar to upper Columbia River spring-run
 7854 Chinook salmon, middle Columbia River spring-run Chinook salmon adults enter freshwater
 7855 from early spring, with the peak run occurring in mid-May, and reach the upper Columbia River
 7856 tributaries from April through July. Some males return to natal streams after one winter at sea;
 7857 however, the 4- and 5-year-old adults are the majority of the run. The adults then hold in the
 7858 tributaries until spawning in the late summer, peaking in mid-late August. Adults die within
 7859 about 1 week after spawning.



7860
7861 **Figure 3-126. Freshwater Life Phases of Middle Columbia River Spring-Run Chinook Salmon**
7862 **Evolutionarily Significant Unit**

7863 Source: NMFS (2007, 2018)

7864 ***Sockeye Salmon***

7865 Upper Columbia River Sockeye Salmon

7866 Upper Columbia River sockeye salmon are not ESA-listed. Currently, Lake Wenatchee, in the
7867 Wenatchee Basin, and Lake Osoyoos, in the Okanogan Basin, are the two main sockeye
7868 salmon-producing lakes in the Columbia River Basin; officially they constitute separate ESUs:
7869 the Lake Wenatchee Sockeye Salmon ESU and the Okanogan River Sockeye Salmon ESU. Upper
7870 Columbia River sockeye salmon migrate through as many as nine dams on their migratory route
7871 to and from the Pacific Ocean; four CRS projects and up to five PUD owned mainstem dams
7872 (Wells Dam is owned and operated by Douglas County PUD; Rocky Reach Dam and Rock Island
7873 Dam which are owned and operated by Chelan County PUD; and Wanapum Dam and Priest
7874 Rapids Dam which are owned and operated by Grant County PUD).

7875 Anadromous juveniles will rear in their natal lakes for one to three years before outmigrating.
7876 Anadromous Upper Columbia River sockeye salmon juveniles migrate to the ocean from April
7877 through early July, with peak migration typically occurring in mid-April to early May. Adult
7878 sockeye salmon will spawn from September through October in the lakeshore gravels.

7879 Okanogan sockeye salmon are currently the most abundant sockeye salmon stock in the
7880 Columbia River Basin. Most Okanogan sockeye salmon rear in Osoyoos Lake, which spans the
7881 U.S.-Canada border. Production of Okanogan sockeye salmon occurs largely in British Columbia.

7882 The majority of Wenatchee sockeye spawn in the White River and Little Wenatchee River, with
7883 some spawning also occurring in the Napeequa River (WDFW 2020). These fish rear in Lake
7884 Wenatchee, a natural lake on the Wenatchee River in Washington State before outmigrating to
7885 the ocean.

7886 ***Coho Salmon***

7887 Upper Columbia River Coho Evolutionarily Significant Unit

7888 Upper Columbia River Coho are not-ESA listed.

7889 Upper Columbia River coho pass the four lower Columbia River dams. While originally these fish
7890 were sourced from hatchery coho programs, there are hatchery releases and natural spawning
7891 now occurs in the Yakima, Wenatchee, Entiat, and Methow basins.

7892 While the coho salmon hatchery production above Bonneville Dam does not affect a defined
7893 ESU or ESUs of coho salmon, it contributes to the rebuilding natural coho salmon populations
7894 (listed and unlisted), as well as benefits and risks to other salmon ESUs and steelhead DPSs.
7895 These programs can provide benefits to the abundance, productivity, and spatial structure of
7896 coho salmon, as well as provide benefits to other species of salmon and steelheads through
7897 marine-derived nutrients from the adult carcasses, cleaning and transport of spawning gravels,
7898 and as a prey base for other salmon and steelheads. However, they also present risks to these
7899 other species in the form of ecological interactions, including competition for scarce resources
7900 and direct and/or indirect predation. Additionally, the hatchery facilities where these programs
7901 are reared and released pose risks associated with delaying or blocking migration of adult and
7902 juvenile fish, as well as risks from water withdrawal and effluent discharge.

7903 Snake River Coho Evolutionarily Significant Unit

7904 Snake River Coho are not ESA-listed.

7905 Snake River coho pass the four lower Snake dams as well as the four lower Columbia River
7906 dams. While originally these fish were sourced from hatchery coho programs, there is natural
7907 spawning that occurs now in the Snake basin tributaries.

7908 While the coho salmon hatchery production above Bonneville Dam does not affect a defined
7909 ESU or ESUs of coho salmon, it contributes to the rebuilding natural coho salmon populations
7910 (listed and unlisted), as well as benefits and risks to other salmon ESUs and steelhead DPSs.
7911 These programs can provide benefits to the abundance, productivity, and spatial structure of
7912 coho salmon, as well as provide benefits to other species of salmon and steelheads through
7913 marine-derived nutrients from the adult carcasses, cleaning and transport of spawning gravels,
7914 and as a prey base for other salmon and steelheads. However, they also present risks to these
7915 other species in the form of ecological interactions, including competition for scarce resources
7916 and direct and/or indirect predation. Additionally, the hatchery facilities where these programs
7917 are reared and released pose risks associated with delaying or blocking migration of adult and
7918 juvenile fish, as well as risks from water withdrawal and effluent discharge.

7919 **Other Non-Endangered Species Act–Listed Anadromous Fish**

7920 ***Pacific Lamprey***

7921 The Pacific lamprey (*Entosphenus tridentatus*), an anadromous species that is parasitic during
7922 its ocean phase. It is the most widely distributed lamprey species on the West Coast (Meeuwig
7923 et al. 2004). Pacific lamprey occur within the Columbia and Snake Rivers. It was estimated that
7924 the population of lampreys in the 1960s and 1970s may have been as many as 1 million adults
7925 at Bonneville Dam (Columbia River Inter-Tribal Fish Commission [CRITFC] 2011). However, due
7926 to several factors, including impediments to passage, Pacific lamprey abundance declined
7927 significantly in the Columbia River Basin to near extirpation in some tributaries (CRITFC 2011a).
7928 The Pacific lamprey is not a federal ESA-listed species, but it is a threatened species by the State
7929 of Idaho (IDAPA 13.01.06). Pacific lamprey were listed as an Oregon State sensitive species in
7930 1993. In December 2004, the USFWS ruled there was not substantial scientific or commercial
7931 information to warrant a Federal listing of Pacific lamprey (69 FR 77158).

7932 Pacific lamprey may migrate through as many as eight Columbia River System projects within
7933 the Columbia and Snake Rivers along their migratory route to and from the Pacific Ocean.
7934 Individual Pacific lamprey have been detected as far upstream as the Salmon River subbasin.
7935 However, Pacific lamprey do not necessarily return to natal locations, but often return to other
7936 river systems in the Pacific Northwest. Lamprey occupancy is constrained to below dams that
7937 lack fish passage on the Columbia and Snake Rivers (Moser and Close 2003).

7938 All lamprey begin life in freshwater and share similar characteristics as ammocoetes (i.e.,
7939 larvae), but they exhibit different life histories as they develop. Time to hatch varies based on
7940 water temperature, which is an important factor for lamprey embryonic and larval
7941 development. Effects of temperature on larval hatching and development were examined and
7942 an increase in abnormalities occurred at a temperature of 22°C, while zero development
7943 occurred at 4.85°C. The optimal temperature for this study was found to be 18°C (Meeuwig et
7944 al. 2005). After emerging, larvae will eventually drift downstream to locations of low velocity
7945 and fine silt and begin the burrowing phase (Brumo 2006).

7946 Larval lamprey phase is strongly associated with stream and river sediments. Larvae burrow in
7947 sediments for 3 to 7 years after hatching, where they filter feed on detritus and organic
7948 material. Larval lamprey prefer areas with accumulated deep, fine substrates (McIlraith et al.
7949 2017). Lamprey may spend up to 10 years as larvae prior to transformation to juvenile phase
7950 (called macrophthalmia) and outmigration. Thus, the availability of suitable habitat for larvae is
7951 critical to conservation. The effects of contaminants in sediments on Pacific lamprey larvae may
7952 impact survival; bioaccumulation of contaminants is occurring in the larval life stage (Nilsen et
7953 al. 2015). They gradually migrate downstream, moving primarily at night, seeking coarser
7954 sand/silt substrates and deeper water as they continue to grow and enter their next life stage.
7955 The Bonneville and The Dalles pools provide habitat and rearing areas for larval Pacific lamprey,
7956 with evidence being that lamprey were detected at river mouths in these pools, as well as in
7957 the shallow water pool margins in the Bonneville pool (Jolley et al. 2014). The river mouths
7958 provide an important habitat for Pacific lamprey larvae, but they are at risk in this environment

7959 because of the potential for stranding (Jolley et al. 2014). Notably, breaching Condit Dam
7960 provided habitat for lamprey in the Bonneville Reservoir at the mouth of the White Salmon
7961 River (Jolley et al. 2014).

7962 Metamorphosis for juveniles occurs from July to December as they develop eyes, teeth, and
7963 become free swimming (Jolley, Silver, and Whitesel 2012). As juveniles mature into adults, they
7964 begin their migration to saltwater (69 FR 77158). Outmigrant collections at Bonneville Dam
7965 indicate a large winter (January to March) peak, with a slightly smaller peak in June. Far fewer
7966 metamorphosed lamprey are seen in July and August (McIlraith et al. 2017).

7967 After spending one to three years in the ocean, Pacific lamprey return to freshwater between
7968 February and June (69 FR 77158). Upstream migration by adult lamprey may be influenced by
7969 an unknown combination of temperature, discharge, and chemical cues. Adults spend multiple
7970 months in the estuary before moving into freshwater habitats. Adult passage at Bonneville Dam
7971 for Pacific lamprey typically occurs between May and late August, peaking in July. Most Pacific
7972 lamprey take about 2 months to migrate upstream through the Columbia River System projects
7973 (McIlraith et al. 2017). Radio telemetry and PIT tag studies have found there is substantial
7974 attrition of fish between mainstem dams during the upstream adult migration in the Columbia
7975 River (Moser and Close 2003; Keefer et al. 2009). The ability to pass multiple dams to reach
7976 spawning locations in the upper reaches of the Columbia and Snake River Basins may be
7977 dependent on a variety of factors, including body size, migration timing, and genetic variation
7978 (Keefer et al. 2009; Hess et al. 2014).

7979 Pacific lamprey are thought to overwinter and remain in freshwater for approximately 1 year
7980 before spawning (69 FR 77158). Adult Pacific lamprey overwinter in locations typically
7981 consisting of deep pools with rock cover (McIlraith et al. 2017). Spawning occurs over many
7982 days in gravel-bottomed streams at the upstream end of riffle habitat (69 FR 77158).

7983 **American Shad**

7984 American shad (shad; *Alosa sapidissima*) is a non-native fish that was introduced to the Pacific
7985 Northwest from eastern North America in the 1880s (Fuller and Neilson 2018a). Shad is an
7986 anadromous member of the Clupeidae family, which includes herring and sardine (Fuller and
7987 Neilson 2018a). Shad can reach 29 inches long and 12 pounds with a maximum life span of 13
7988 years (Froese and Pauly 2018). Adult and juvenile shad feed on zooplankton and fish eggs. This
7989 species is not federally or state listed.

7990 Shad are now distributed throughout the mainstem Columbia, Snake, and Willamette Rivers,
7991 but they have not been recorded in all tributaries of these rivers. The Columbia River supports
7992 the largest population of shad in the world (Sanderson, Barnas, and Rub 2009; Hinrichsen et al.
7993 2013; Froese and Pauly 2018).

7994 Shad migration and juvenile survival varies with water temperature and river discharge; once
7995 water temperatures reach 16°C, returning adults spawn between June and August in shallow
7996 water over sand or gravel (Hinrichsen et al. 2013). Shad require a temperature range of 13°C to

7997 26°C for eggs and juveniles to successfully grow (Hinrichsen et al. 2013). Hinrichsen et al. (2013)
7998 found that lower dam discharges allowed more adult shad to migrate farther upstream due to
7999 slower water, which requires less energy to swim through. Juveniles use all portions of rivers;
8000 however, they are more abundant in off-channels with dense aquatic vegetation.

8001 Juvenile shad outmigrate to the ocean in the fall when they are between 1 to 4 inches (2.5 to
8002 10.2 cm) long (Lower Columbia Fish Recovery Board 2004c) and return as 3- to 4-year-old
8003 adults. A portion of the adult shad return to sea after spawning (Lower Columbia Fish Recovery
8004 Board 2004c).

8005 Shad are considered competitors with native fish particularly because both adult and juvenile
8006 shad feed on zooplankton that native fish would otherwise consume (Lower Columbia Fish
8007 Recovery Board 2004c; Haskell, Tiffan, and Rondorf 2013). The large population of shad within
8008 the Columbia and Snake Rivers consume as much as 30 percent of the zooplankton present in
8009 these rivers (Haskell, Tiffan, and Rondorf 2013). The large number of juvenile shad present in
8010 the river basin may subsidize the diets of non-native fish such as bass, catfish, and walleye that
8011 feed on fish, including native fish (Harvey and Kareiva 2005; Sanderson, Barnas, and Rub 2009),
8012 thereby contributing to an increasing number of non-native aquatic predators. Juvenile shad
8013 may compete with juvenile salmon and steelhead for backwater habitat (Lower Columbia Fish
8014 Recovery Board 2004c).

8015 Migrating adult shad may occupy fish ladders during periods when adult salmon and steelhead
8016 are migrating upstream (Lower Columbia Fish Recovery Board 2004c; Hinrichsen et al. 2013);
8017 raising flows at The Dalles' east fish ladder appears to effectively accommodate adult salmon to
8018 avoid overcrowding with adult shad.

8019 ODFW and WDFW promote American shad as a recreational fishing opportunity (ODFW 2018a;
8020 WDFW 2018), as well as a managed commercial shad fishery (Lower Columbia Fish Recovery
8021 Board 2004c). However, the commercial fishery is limited because adult shad migration
8022 overlaps with adult salmon and steelhead migration (Lower Columbia Fish Recovery Board
8023 2004c). No efforts are underway to eradicate shad in the Columbia River Basin.

8024 It is important to note that shad are generalists that tolerate a wide range of conditions and
8025 CRS projects are not likely to change the population numbers but could influence their
8026 migrations and distributions that affect interactions with native fish.

8027 **3.5.2.4 Resident Fish**

8028 As described in Section 3.2.1.1, resident fish are fish that spend their entire lives in freshwater;
8029 they are either fluvial (using only rivers for spawning and rearing) or adfluvial (using lakes for
8030 feeding and rivers for spawning), or they may simply live in one habitat type, such as a lake or
8031 river, their entire life cycle. The kinds and numbers of resident fish vary considerably across the
8032 basin. Many species interact with each other and their habitats to form local/regional fish
8033 communities. Some of these species are important for recreational, cultural, and commercial
8034 harvest. Approximately two-thirds of the fish species in the Columbia River Basin are non-native

8035 and the extent of their influence and impacts to native fish assemblages is not well understood
8036 (Independent Scientific Advisory Board [ISAB] 2008).

8037 In this section, key fish species in the study area will be discussed, including life history, status,
8038 and a general description of their interaction with Columbia River System projects. Then,
8039 because (1) effects to resident fish are most effectively evaluated by regions or communities; (2)
8040 they are managed on a more localized scale than anadromous fish; and (3) effects from projects
8041 tend to vary widely across the Columbia River Basin. The resident fish residing within the
8042 Columbia River Basin are generally described, followed by a description of the regional resident
8043 fish communities in which they reside. Additionally, the species that are ESA-listed (bull trout
8044 and Kootenai River white sturgeon) are discussed in their own sections within each region.

8045 **ENDANGERED SPECIES ACT–LISTED RESIDENT FISH**

8046 An inventory of the ESA-listed resident species and their designated critical habitat in the study
8047 area appears in Table 3-59. Details on distribution, population status, and threats to each of
8048 these species appear in the *Federal Register* notices that NMFS and the USFWS provide for all
8049 listing actions; these are cited in the table. Species status and relevant CRSO study area
8050 information appear in their respective subsections later in this section.

8051 **Table 3-59. Status and Critical Habitat of Resident Columbia River Basin Endangered Species**
8052 **Act–Listed Species**

Species and ESU or DPS	ESA-Listing Status	Critical Habitat Designation
Bull Trout Columbia River DPS (<i>Salvelinus confluentus</i>) ^{1/, 2/, 3/}	Threatened 1999	2004
Kootenai River White Sturgeon (<i>Acipenser transmontanus</i>) ^{1/, 2/}	Endangered 1994	2008

8053 1/ State-listed threatened: Idaho (IDAPA 13.01.06).

8054 2/ State-listed species of concern: Montana (MFWP 2018).

8055 3/ State Species of Concern: Washington (WDFW)

8056 **Bull Trout**

8057 Bull trout (*Salvelinus confluentus*) are members of the char genus and require very cold, clear
8058 water. Smaller juveniles eat terrestrial and aquatic insects; as they grow, they shift to eating
8059 fish, with a preference for whitefish, sculpins, and other trout as well as anadromous fish eggs,
8060 alevin, fry, smolts, and carcasses (USFWS 1997). Bull trout exhibit multiple life history patterns
8061 involving movements and migrations that reflect a high degree of local site fidelity (USFWS
8062 2008b). Bull trout in the Columbia River Basin can be resident or migratory. Resident bull trout
8063 spend their entire lives in the same stream, while migratory bull trout spend most of their time
8064 in lakes, reservoirs (adfluvial), or large rivers (fluvial). Adult bull trout migrate upstream to
8065 spawn in the fall in streams with cold, clear water, and eggs hatch in late winter or early spring.
8066 Juveniles rear in the spawning tributaries for 1 to 4 years, and then in migratory life history
8067 patterns, juveniles move back downstream to larger rivers or lakes. Bull trout will repeat spawn
8068 from sexual maturity of 4 to 7 years throughout their life span, which can reach 12 years.

8069 The bull trout was ESA-listed as threatened in 1999 (64 FR 58910), which was reaffirmed in
8070 2008 in its status review (USFWS 2008b), with critical habitat identified in 2004 (70 FR 63898)
8071 and updated in 2010 (75 FR 6398). The recovery plan developed in 2015 outlined reasonable
8072 actions to recover and protect bull trout (USFWS 2015b). Bull trout occur throughout the
8073 Columbia and Snake River Basins in Washington, Oregon, Idaho, and Montana (USFWS 2015).
8074 Bull trout critical habitat, which describes specific locations and elements of the environment
8075 essential for the conservation and recovery of the species, was designated for the entire
8076 mainstem Columbia River upstream to Chief Joseph Dam and mainstem Snake River upstream
8077 to Brownlee Dam, as well as upper tributaries of both rivers (USFWS 2015).

8078 The USFWS status review (2008b) reported bull trout were generally stable range-wide, with
8079 some core area populations decreasing, some stable, and some increasing. Since the listing of
8080 bull trout as threatened in 1999, there has been little change in the distribution of bull trout in
8081 the coterminous United States, with the exception of successful reintroduction into the
8082 Clackamas River, and occupied bull trout core areas have not been extirpated since the species
8083 listing (USFWS 2015).

8084 In the study area, bull trout occur in substantial populations in the headwater regions, including
8085 the Flathead, Clark Fork, Pend Oreille, and Kootenai River Basins. In the Columbia River, bull
8086 trout occasionally appear in the upper river from the U.S.-Canada border to Grand Coulee Dam,
8087 and the mainstem provides feeding, migration, and overwintering habitat for populations in the
8088 Wenatchee, Methow, and Entiat populations (USFWS 2015) between Chief Joseph Dam and
8089 McNary Dam. The Snake, Salmon, and Clearwater Rivers provide feeding, migration, and
8090 overwintering habitat as well as migration connections for several populations of bull trout.
8091 Below McNary Dam, very few bull trout have been observed in the mainstem (Fish Passage
8092 Center 2018a, 2018b).

8093 **Kootenai River White Sturgeon**

8094 The Kootenai River white sturgeon (*Acipenser transmontanus*) is a land-locked population of
8095 white sturgeon confined to just 168 river miles in Montana and Idaho in the United States and
8096 in British Columbia, Canada. Kootenai River white sturgeon are large, long-lived fish with a
8097 prehistoric appearance due to rows of bony plates called scutes on their sides. The maximum
8098 observed size of Kootenai River white sturgeon based on growth data is about 9 feet, and they
8099 could theoretically reach almost 11 feet (Paragamian, Beamesderfer, and Ireland 2005). White
8100 sturgeon have sensitive, whisker-like barbels on their snouts that help them detect prey with
8101 their downward facing mouth on the riverbed (Scott and Crossman 1973). Kootenai River white
8102 sturgeon are opportunistic feeders that prey on a variety of organisms available to them;
8103 juveniles prefer small organisms in the substrate such as invertebrates and insect larvae, then
8104 as adults their diet shifts mainly to fish with some clams, snails, and aquatic insects (USFWS
8105 1999). Kootenai River white sturgeon were harvested for food, caviar, and for sport until a
8106 decline in catch and subsequent harvest restrictions limited the number of white sturgeon
8107 taken (Scott and Crossman 1973).

8108 The population ranges from Kootenai Falls (approximately 31 RM downstream of Libby Dam) to
8109 Corra Linn Dam at the outlet of Kootenay Lake. Since the last ice age, Kootenai River white
8110 sturgeon have been isolated from other downstream white sturgeon populations in the
8111 Columbia River Basin by a natural barrier at Bonnington Falls, downstream from Kootenay Lake
8112 (USFWS 1999).

8113 The Kootenai River population of white sturgeon was ESA-listed as endangered on September 6,
8114 1994. It is listed as a Montana Species of Special Concern (MFWP 2018) and an Idaho
8115 endangered species (IDAPA 13.01.106). Critical habitat for this species was established in 2001,
8116 and then expanded in 2008 to include 18.3 river miles of the Kootenai River within Boundary
8117 County, Idaho. In January 2018, the USFWS initiated a 5-year status review (83 FR 3104), and a
8118 revised recovery plan was completed in September 2019 (USFWS 2019).

8119 The Libby Project is the only Columbia River System project that interacts with Kootenai River
8120 white sturgeon. Since its completion in 1974, the Libby Project has greatly changed flow
8121 regimes of the Kootenai River compared to flow regimes prior to dam construction. The
8122 operation of the Libby Project has reduced peak flow magnitude, changed the timing
8123 (seasonality) of the hydrograph, and retained upstream sediment supply. Kootenai River
8124 temperature and nutrient regimes, which support primary productivity of the food web, have
8125 also been modified (USFWS 1999).

8126 **NON-ENDANGERED SPECIES ACT–LISTED RESIDENT FISH**

8127 This section includes a review of Columbia River Basin fish species that are not ESA-listed. Some
8128 species that may have a state-listing status or have been identified as a species of interest by
8129 the public during scoping, are considered key species and discussed specifically in detail. These
8130 key species are categorized as either native or non-native. Other species are described as
8131 groups or communities of fish.

8132 **Key Native Fish Species**

8133 ***White Sturgeon (Columbia River)***

8134 White sturgeon are large, long-lived fish with a prehistoric appearance due to rows of bony
8135 plates called scutes along their bodies. They are considered the largest freshwater fish in North
8136 America and are an important cultural, recreational, and commercial resource in the Columbia
8137 River Basin. Unlike the Kootenai River population of white sturgeon, white sturgeon in the
8138 Columbia River are not ESA-listed. They occasionally appear in marine waters and typically live
8139 in the Columbia River from the mouth to the upper Columbia River in Canada, as well as the
8140 Snake River up to Shoshone Falls. They use the Willamette River up to and above Willamette
8141 Falls and other lower Columbia River tributaries (Hanson et al. 1992). Adults are opportunistic,
8142 bottom-oriented feeders and primarily eat invertebrates and fish. They have unique
8143 adaptations for bottom feeding that include ventral barbels and a protrusible mouth.

8144 White sturgeon reach sexual maturity when they are older and larger compared to most fish
8145 species found in freshwater, with males maturing at 12 to 25 years of age and females at 15 to
8146 30 years (Bajkov 1949; Scott and Crossman 1973; Galbreath 1985; Hanson et al. 1992; Welch
8147 and Beamesderfer 1993; IPC 2005). Reproductive frequency also varies between sexes; males
8148 can reproduce every 2 to 4 years, while females were thought to reproduce no more frequently
8149 than every 5 years (Conte et al. 1988; Chapman, VanEenennaam, and Doroshov 1996; Anders et
8150 al. 2002), though more recent information suggests females can spawn more frequently than
8151 every four years. Spawning occurs between April and July during the highest spring flows and
8152 when temperatures reach 12°C to 14°C (Hanson et al. 1992; Parsley et al. 1993; Parsley and
8153 Beckman 1994). They are broadcast spawners, which means females typically release eggs that
8154 are fertilized when males release milt (i.e., sperm) over them. Eggs adhere to river substrate
8155 and hatch after 8 to 15 days, depending on water temperature (Brannon et al. 1985). High
8156 water velocity is key to spawning site selection (NW Council 2013), and sufficient flows during
8157 key spawning times are important. Hatched embryos are called yolk-sac larvae; they have a yolk
8158 sac that provides sustenance as the larvae hide among the substrate and seek protection from
8159 predators. Small spaces in the substrate are important for this life stage. Once the yolk sac is
8160 absorbed, they begin a downstream dispersal and transition to external foods, primarily benthic
8161 macroinvertebrates, for the next developmental stage (Brannon et al. 1984; Buddington and
8162 Christofferson 1985; Muir et al. 2000; Hildebrand et al. 2016).

8163 Growth during larval stage is dependent on temperature, food availability, location, and genetic
8164 variability (CRWSPF 2013; Golder 2003a, 2005a, 2006a, 2000b), with optimal temperatures at
8165 14°C to 17°C. Sturgeon at this stage prefer the deeper, slower velocity areas (McCabe and
8166 Hinton 1991; Miller et al. 1991; Parsley et al. 1992) and depend on the currents to transport
8167 them into the rearing areas. For white sturgeon, the larval stage ends once the fish has grown
8168 enough to complete development of their fins and scutes. White sturgeon recruitment success
8169 through this life stage is correlated with sufficient flows during the spawning to larval growth
8170 timeframe. This is considered the juvenile stage, and juvenile sturgeon look like a miniature
8171 version of adult sturgeon. Juveniles are most often captured within the thalweg (i.e., deepest
8172 portion of the river) and rarely adjacent to the thalweg in shallower water (Parsley et al. 1992).
8173 Juveniles transition to a sub-adult life stage where they are not yet sexually mature but can fully
8174 access marine environments, and then finally considered adults at the onset of sexual maturity.

8175 Adult sturgeon have a tendency to remain in localized areas for extended periods (Golder
8176 Associates Ltd. 2010a; Nelson and McAdam 2012; Nelson et al. 2013a, 2013b; BC Hydro 2016a)
8177 and show repeated movements between specific locations (Parsley et al. 2008; Golder
8178 Associates Ltd. 2010a; Robichaud 2012; Nelson et al. 2013a). Large-scale movements within
8179 basins are usually associated with specific life functions such as feeding, spawning, and
8180 overwintering (Apperson and Anders 1990; Brannon and Setter 1992).

8181 While the Columbia River downstream of Bonneville Dam supports a wild and self-sustaining
8182 white sturgeon population segment, abundance elsewhere in the Columbia River Basin is
8183 limited. The population structure of white sturgeon in the Columbia River Basin has been
8184 greatly altered by overfishing and extensive dam construction. The construction of dams has

8185 substantially modified sturgeon habitat by reducing quality, suitability, and connectivity
8186 (Hildebrand et al. 2016). White sturgeon population segments that reside in reservoirs are cut
8187 off from the estuary and ocean by hydroelectric development. These populations are
8188 recruitment limited and, in general, less abundant when compared to white sturgeon below
8189 Bonneville Dam. Based on marking studies and dam counts, white sturgeon do not typically
8190 move freely between impoundments.

8191 **Burbot**

8192 Burbot (*Lota lota*) is the only freshwater member of the cod family. They are a native predatory
8193 fish that is well suited to deep water habitats of large, cold rivers and reservoirs. Burbot
8194 primarily feed at night and are voracious predators, but opportunistic feeders. They are unique
8195 in that they spawn during the winter, over fine gravel, sand, or silt, and sometimes under the
8196 ice. In rivers, burbot spawn in low velocity areas in main channels or inside channels behind
8197 deposition bars. The semi-buoyant eggs are broadcast over the substrate and may drift, but
8198 eventually settle into the substrate. Burbot free embryos or yolk-sac larvae remain on the
8199 substrate until they have nearly exhausted their yolk reserves, at which point they enter the
8200 water column and become pelagic. Burbot fry feed on zooplankton and small aquatic
8201 macroinvertebrates, and as they grow, their diet shifts to include fish.

8202 In the CRSO area, burbot are found in the Kootenai River in northern Idaho and Montana, and
8203 in the Columbia River in Washington primarily above Chief Joseph Dam in Rufus Woods Lake
8204 and Lake Roosevelt upstream to the U.S.-Canada border. Thanks to intensive restoration efforts
8205 by the Kootenai Tribe of Idaho, Idaho Fish and Game (IDFG), and fishery professionals from
8206 British Columbia, and Montana, a harvest fishery for Burbot was opened in the Kootenai River
8207 basin in Idaho on January 1, 2019. The fishery had been closed since 1992 in response to drastic
8208 declines in Burbot abundance. The decision to open the fishery hinged on the empirically
8209 derived estimate that restoration targets for the number of adult Burbot in the river (i.e.,
8210 17,500 spawning adults) was met in 2019. Furthermore, with continued growth and success of
8211 the restoration program, it is estimated that the adult population will further grow in
8212 abundance, exceeding original restoration targets in coming years. It is listed as a State of Idaho
8213 endangered species (IDAPA 13.01.06) and is considered a species of concern in the State of
8214 Montana. Operated by the Kootenai Tribe of Idaho, the Twin Rivers Hatchery opened in 2014 at
8215 the confluence of the Moyie and Kootenai Rivers in Idaho to help produce burbot for stocking
8216 the Kootenai River in multiple locations in British Columbia, Idaho, and Montana.

8217 Burbot abundance can actually increase following impoundment of reservoirs because of
8218 increased larval survival and adult foraging opportunities (Bonar et al. 2000) but can decline
8219 downstream of dams. As winter spawners, reservoir burbot populations can be sensitive to
8220 drawdowns in winter and early spring.

8221 **Columbia River Redband Rainbow Trout**

8222 Columbia River redband rainbow trout (also known as inland redband trout [*Oncorhynchus*
8223 *mykiss gairdneri*]) are a native subspecies of *O. mykiss*, the same species as steelhead and

8224 rainbow trout. Therefore, they can have the same diverse life histories; populations may have
8225 individuals that exhibit anadromous, adfluvial, fluvial, and resident behaviors (Interior Redband
8226 Conservation Team 2016). Researchers have documented the demographics and reproductive
8227 characteristics of both and resident histories for Columbia River redband trout populations
8228 (Holecek et al. 2012). Columbia River redband trout are typically a stream-resident fish that
8229 have short migration either within the same stream or often into smaller tributaries. In areas
8230 not blocked by unpassable barriers, the resident and anadromous life history forms of redband
8231 trout and steelhead occur together and are known to interbreed. The species spawns in gravel-
8232 bottomed, fast-flowing, well-oxygenated rivers and streams. The maximum life span is typically
8233 6 years, and the average length is 12 to 16 inches (30 to 41 cm). Redband trout feed on aquatic
8234 insect larvae, crayfish, zooplankton, fish eggs, and some terrestrial insects that drop into the
8235 water (Behnke 1992).

8236 Columbia River redband trout occur in the interior Columbia River Basin from east of the
8237 Cascades upstream to geologic barriers such as Shoshone Falls on the Snake River (Behnke
8238 2002). Redband occur above Kootenai Falls in Montana and naturally reproducing, genetically
8239 pure populations still exist in the Kootenai River downstream of Libby Dam in Callahan Creek,
8240 East Fork Yaak River, and tributaries of the Fisher River. Lake Roosevelt and tributaries to the
8241 Columbia River that flow into the lake support numerous populations of Redband trout with
8242 diverse life history strategies. Redband trout are the most widely distributed native salmonid in
8243 the Columbia River Basin (Thurow et al. 2007). They are likely to encounter dams in the interior
8244 Columbia River Basin; in some areas, populations have become isolated and have developed
8245 alternative life history strategies (e.g., rearing in reservoirs instead of in a stream or river)
8246 (Thurow et al. 2007; Holecek and Scarnecchia 2013).

8247 **Westslope Cutthroat Trout**

8248 Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) are native trout that are a genetically
8249 distinct subspecies of *O. clarkii*. They exhibit multiple life history forms, including adfluvial,
8250 fluvial, and resident. They typically spawn in tributary streams in spring when water
8251 temperature is about 10°C and flows are high with spring run-off (Committee on the Status of
8252 Endangered Wildlife in Canada 2016a). Westslope cutthroat trout have specific habitat
8253 requirements during various life history stages necessary to maintain populations. These
8254 requirements include cold, clean, well-oxygenated water; clean, well-sorted gravels with
8255 minimal fine sediments for successful spawning; temperatures below 21°C; and a complex
8256 instream habitat structure such as undercut banks, pool-riffle habitat, and riparian vegetation
8257 (Committee on the Status of Endangered Wildlife in Canada 2016a). The average length of
8258 westslope cutthroat trout is 8 to 12 inches (20 to 30 cm). They mature within 4 to 6 years and
8259 may live as long as 12 years. Westslope cutthroat trout spawn between March and July. Their
8260 diet is primarily aquatic invertebrates, with larger trout occasionally preying on other fish
8261 (Committee on the Status of Endangered Wildlife in Canada 2016a). The species can produce
8262 offspring with non-native rainbow trout or their hybrid progeny and descendants (USFWS
8263 2003).

8264 Westslope cutthroat trout occur in the upper Kootenai River and the Clearwater and Salmon
8265 River Basins (McIntyre and Reiman 1995). They were common upstream of Libby Dam after
8266 impoundment, but are now uncommon because of dam operation, adverse interactions with
8267 non-native fish species, and habitat modifications. Flow fluctuations or low nutrient levels have
8268 impacted aquatic insects, a key prey item, in the Kootenai River (Corps 2006). Lake Roosevelt
8269 and its tributaries support fluvial, fluvial-adfluvial, and lacustrine-adfluvial life history types.

8270 **Northern Pikeminnow**

8271 Northern pikeminnow (pikeminnow; *Ptychocheilus oregonensis*) is a native, resident,
8272 freshwater fish that occurs throughout the Pacific Northwest, United States, and British
8273 Columbia, Canada (Gadomski et al. 2001; Froese and Pauly 2018). Northern pikeminnow is a
8274 member of the Cyprinidae family, which includes minnows and carps (Gadomski et al. 2001;
8275 Froese and Pauly 2018). This fish species prefers slow water in lakes and rivers. In as little as
8276 three years, pikeminnow can reach full maturity (Lower Columbia Fish Recovery Board 2004b),
8277 with a maximum size of 600 mm, 2.5 kg mass, and they can live up to age 16 below Bonneville
8278 as well as in the Columbia and Snake reservoirs (Rieman and Beamesderfer 1990; Parker et al.
8279 1995). Spawning occurs primarily when temperatures rapidly rise from 14°C to 18°C (June and
8280 July) (Gadomski et al. 2001). Gadomski et al. (2001) found most pikeminnow spawn on dam
8281 tailraces rather than elsewhere in the reservoirs. Both larval and juvenile pikeminnow rear
8282 along the shoreline where water velocities are low (Gadomski et al. 2001). Poe et al. (1991)
8283 found smaller Northern pikeminnow consumed primarily invertebrates, which increased with
8284 increasing size. Fish above 375 mm fork length ate more salmonids than invertebrates and
8285 other fishes combined (based on percent weight). Salmonids composed 21 percent of diet at
8286 300 mm FL and up to 83 percent of diet of larger fish (475 mm) (Vigg et al. 1992, as cited in
8287 Beamesderfer et al. 1996) Juvenile pikeminnow feed primarily on invertebrates and become
8288 piscivorous around 2 years of age (Fritts and Pearsons 2006; Martinez Garcia 2014). Smaller
8289 pikeminnow, less than 12 inches (30 cm) long, eat chiefly invertebrates, while larger
8290 pikeminnow prefer smaller fish such as salmon, sculpins, trout, perch, and suckers (Lower
8291 Columbia Fish Recovery Board 2004b). According to Beamesderfer, Ward, and Nigro (1996),
8292 pikeminnow prey exponentially more on juvenile salmon as pikeminnow increase in size.

8293 Pikeminnow are important in the Columbia River region as a piscivorous predator of
8294 outmigrating salmon smolts. Because of this predation on salmon and steelhead smolts,
8295 pikeminnow are harvested as part of Bonneville's pikeminnow reward program. Pikeminnow
8296 thrive in the Columbia River Basin primarily because of their ability to adapt to changing water
8297 depths, flows, and temperature levels; and because pikeminnow consume a diversity of prey
8298 species (Lower Columbia Fish Recovery Board 2004b). Northern Pikeminnow prefer
8299 temperatures 16-22°C but are often found in warmer waters (Brown and Moyle 1981).
8300 Reservoirs associated with dams provide warm water and low current areas that benefit
8301 pikeminnow (Martinez Garcia 2014). Salmon and pikeminnow are both native to the basin, but
8302 changes in the system to more reservoir environments favor pikeminnow production and by
8303 increasing the metabolism of these predators, resulting in higher than natural predation rates.
8304 Because of high predation rates on juvenile salmon, pikeminnow have been targeted for control

8305 since 1990 through gillnetting and sport-reward fisheries (ODFW 2018b). These programs have
8306 been successful at removing the larger pikeminnow that predate on juvenile salmon.

8307 **Mountain Whitefish**

8308 Mountain whitefish (*Prosopium williamsoni*) is a native member of the Salmonidae family and is
8309 not an ESA-listed or state-listed species. Mountain whitefish inhabit lakes and large rivers and
8310 medium to large cold mountain streams. As a generalized life history, mountain whitefish
8311 spawn from October through December in stream riffles or on gravel shoals in lakes (Wydoski
8312 and Whitney 2003). Eggs are broadcast into the water column and are distributed throughout a
8313 variety of locations and depths depending on river flow conditions during spawning. Hatching
8314 of the eggs is assumed to start in January and potentially extend until May. Juveniles feed
8315 primarily on aquatic insect larvae in flowing reaches with a cobble gravel substrate, such as the
8316 Hanford Reach of the Columbia River (Wydoski and Whitney 2003). Older juveniles and adults
8317 primarily use deep, fast-moving water over gravel and cobble substrates. Mountain whitefish
8318 may live to 17 years and grow to maximum sizes of 10 to 23 inches (23.4 to 58 cm) (Scott and
8319 Crossman 1998).

8320 Mountain whitefish occur throughout the Columbia River Basin but are rare in the impounded
8321 sections of the Columbia and Snake Rivers. An unknown proportion of mountain whitefish in
8322 the lower, middle, and upper sections of the lower Columbia River undertake long migrations to
8323 spawning areas in other sections of the river (BC Hydro 2014). Mountain whitefish in southern
8324 Idaho disproportionately use larger streams (wider than 49 feet [15 m]) in the Snake River Basin
8325 compared to more northerly locations, where they are more common in smaller streams
8326 (Meyer, Elle, and Lamansky 2009). Fish collection at Lower Monumental, Little Goose, and
8327 Lower Granite Dams from 2012 to 2017 generally resulted in increases in mountain whitefish
8328 catch during this 6-year period, although fewer fish were caught in 2016 and the increases did
8329 not occur every year. Whitefish contribute to recreational fisheries throughout the region.

8330 **Other Native Fish Species**

8331 A variety of native minnow, sculpins, and sucker species contribute ecologically to the fish
8332 communities in the study area. Native minnows and sculpins tend to be small and are
8333 important prey items for many native or recreationally important key predator species. Suckers
8334 typically grow larger and feed on aquatic insects or algae, but juveniles and adults provide a key
8335 food source for piscivorous fish, birds, and mammals.

8336 Native minnow species (Cyprinidae family) occur in freshwater streams, lakes, and small- to
8337 medium-sized rivers in the Columbia River Basin. Minnows occur in shallow waters, around
8338 inshore areas of lakes (peamouths, longnose dace, leopard dace, redbreast shiner, tui chub,
8339 chiselmouth, and young Northern pikeminnow), the slow parts of small- to medium-sized rivers
8340 (peamouths, longnose dace, speckled dace, leopard dace, Oregon chub, tui chub, and redbreast
8341 shiner), swiftly flowing creeks (Umatilla dace, longnose dace, and chiselmouth), and in riffles
8342 (speckled dace) (International Union for Conservation of Nature 2013). As a generalized life
8343 history, minnows spawn at 1 or 2 years of age, with peak spawning occurring in late spring and

8344 summer. Most of the species prey on small organisms (zooplankton) or are insectivorous for all
8345 or a portion of their life cycles. Trout-perch (also known as sandroller) is another small fish
8346 species endemic to small to large rivers in the basin with similar requirements.

8347 Sculpins (Cottidae family) are smaller, bottom-dwelling fish in the family Cottidae. Sculpins
8348 occur in cold freshwater streams, lakes, and rivers and are widely distributed in the Columbia
8349 River Basin. Most of these species inhabit medium- or larger-sized streams with moderate to
8350 rapid current, although some species prefer slow-moving parts of streams, rivers, or lake
8351 habitats. Sculpins have been found in springs (mottled and slimy sculpins), lakes (Paiute and
8352 prickly sculpins), stream pools (margined and reticulate sculpins), small rivers (shorthead,
8353 Paiute, prickly, torrent, and reticulate sculpins), medium-sized rivers (shorthead, Paiute, prickly,
8354 torrent, and coastrange sculpins), and large rivers (shorthead, torrent, Columbia, and
8355 coastrange sculpins). The coastrange and prickly sculpins occasionally enter estuaries, while
8356 slimy sculpin have been found in brackish water. As a generalized life history, sculpins spawn at
8357 1 or 2 years of age, with peak spawning occurring between March and May. Juvenile sculpins
8358 initially feed on plankton during their pelagic life stage, transitioning to aquatic insects after
8359 moving to stream or lake bottoms where they spend the majority of their life cycles.

8360 Suckers (Catostomidae family) within the Columbia River Basin include largemouth sucker (also
8361 known as the largescale sucker), bridgelip sucker, longnose sucker, and mountain sucker. None
8362 of these four species are ESA-listed or state-listed. They inhabit a variety of habitats such as
8363 pools and runs of large rivers and lakes (largemouth sucker); lake margins and backwaters as
8364 well as rocky riffles and runs of small rivers (bridgelip sucker); cold, clear deep waters of lakes
8365 and tributary streams (longnose sucker); and rocky riffles and runs of clear mountain creeks
8366 (mountain sucker). These species typically feed on algae, diatoms, insects, amphipods,
8367 mollusks, and may feed on salmon eggs. Young suckers may be preyed upon by some salmon
8368 species (Scott and Crossman 1998).

8369 **Key Non-Native Fish Species**

8370 A non-native or nonindigenous species is a species “not native to a particular area, or found
8371 living outside of historical range” (USGS 2018b). A non-native species can be benign, or it can be
8372 invasive and potentially harmful. Many non-native species in the Columbia River serve as
8373 recreational resources but can cause impacts to native fish through competition and predation.
8374 An invasive species is non-native to the ecosystem and is likely to cause economic or
8375 environmental harm or harm to human health. Invasive species are capable of causing
8376 extinctions of native plants and animals, reducing biodiversity, competing with native
8377 organisms for limited resources, and altering habitats.

8378 **Non-Native Salmon and Trout**

8379 Non-native resident salmon and trout present in the Columbia River Basin include Arctic
8380 grayling (*Thymallus arcticus*), Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*),
8381 brown trout (*Salmo trutta*), golden trout (*O. aguabonita*), lake trout (*Salvelinus namaycush*),
8382 lake whitefish (*Coregonus clupeaformis*), and tiger trout (a hybrid of brook and brown trout)

8383 (Novak 2014; Froese and Pauly 2018; USGS 2018a). Introduced resident salmon and trout can
8384 have a variety of effects on native endangered salmon and trout, including hybridizing (Seiler
8385 and Keeley 2009; Dehaan Schwabe, and Arden 2010; Kanda, Leary, and Allendorf 2011),
8386 predating on native fish (Levin et al. 2002; McHugh and Budy 2006; Schoen, Beauchamp, and
8387 Overman 2012), competing for food and habitat with native fish (McHugh and Budy 2006; Seiler
8388 and Keeley 2009), and introducing parasites and diseases (Krueger and May 1991; Burrill 2014).

8389 Some native and non-native trout species are stocked annually in lakes where they would not
8390 naturally occur within all watersheds of the Columbia River Basin including the Clearwater,
8391 Kootenai, and Salmon River watersheds (USGS 2018a). Hybridization between cutthroat (*O.*
8392 *clarkii*) and rainbow (*O. mykiss*) trout has been documented in drainages throughout Idaho
8393 (Kozfkay et al. 2011). Much of this is unnatural due to past stocking of fertile hatchery rainbow
8394 trout (Weigel et al. 2003, Campbell et al. 2002), and much more limited stocking of fertile
8395 cutthroat trout (Neville and Dunham 2011) in areas where the two species are not naturally
8396 sympatric. Some hybridization also occurs naturally between sympatric populations of
8397 cutthroat trout and rainbow trout (Kozfkay et al. 2007). Most of the research in Idaho suggests
8398 that although hybrids have been detected in many drainages, hybridization and introgression
8399 levels are often low, with few hybrid swarms documented (Meyer et al. 2006; McKelvey et al.
8400 2015). These results have been explained by strong assortative mating observed between
8401 rainbow trout and cutthroat trout and the reduced fitness of hybrids (Henderson et al. 2000;
8402 Gunnell et al. 2008; Kozfkay et al. 2007; Walters 2006; Young et al. 2003). These hybrids are
8403 established in Lake Pend Oreille and the lower Columbia, Clearwater, and Snake Rivers and are
8404 stocked annually in lakes within several watersheds including the Clearwater River (USGS
8405 2018a). In some locations, sterile hybrid trout are stocked to provide recreational fishing
8406 opportunities without substantially altering the established fish communities. The status of
8407 brown trout is unknown (USGS 2018a). Atlantic salmon, brook trout, lake trout, and lake
8408 whitefish were introduced from eastern North America (Novak 2014; USGS 2018a). Brown trout
8409 were introduced from Europe and Asia, and golden trout were introduced from California
8410 (USGS 2018a).

8411 ***Other Non-Native Gamefish***

8412 Many species of non-native warm water fish in the Columbia River Basin were introduced as
8413 recreational game species where they thrive primarily because of habitat modification and the
8414 creation of slow-moving water, reservoirs, and warm water habitat. Smallmouth bass,
8415 largemouth bass, sunfishes, perch, pike, walleye, and catfish provide recreational resources but
8416 have become invasive and compete with or cause predation issues for native fish.

8417 Smallmouth bass and largemouth bass (sunfish; Centrarchid family) were introduced from
8418 eastern North America in the 1920s (Sanderson et al. 2009; Carey et al. 2011; Fuller, Cannister,
8419 and Neilson 2018). They are aggressive, predatory fish that feed on amphibians, fish, birds, and
8420 small mammals. Invertebrates constitute a large part of smallmouth bass diet, particularly
8421 crayfish and other crustaceans (Poe et al. 1991). Preferred spawning habitat for both species
8422 includes slow-water areas of lakes, rivers, or streams in water less than 18 to 20 feet deep.

8423 Once eggs hatch, optimal juvenile fish growth is associated with water temperatures between
8424 26°C and 29°C (Wile 2014). Juvenile bass become piscivorous around 2 years old at
8425 approximately 100-150mm in length (Fritts and Pearsons 2006) and live long life spans. Bass are
8426 now established and breeding throughout the Columbia River Basin, and they continue to be
8427 stocked in some locations (Sanderson et al. 2009; USGS 2018a). Carey et al. (2011) note several
8428 studies that predict the expansion of suitable habitat for bass with warming temperatures,
8429 which could facilitate an increase in bass populations.

8430 Other non-native sunfish present in the Columbia and Snake Rivers include black crappie,
8431 bluegill, pumpkinseed, rock bass, striped bass, warmouth, and white crappie (Froese and Pauly
8432 2018; USGS 2018a). Sunfish occur in streams, lakes, and reservoirs (Froese and Pauly 2018).
8433 Black crappie, striped bass, and white crappie prey on juvenile salmon and native resident fish
8434 as adults and compete with native fish for invertebrates, zooplankton and small fish as juveniles
8435 (Riso 2011; Froese and Pauly 2018; USGS 2018a). Pumpkinseed, rock bass, warmouth, spotted
8436 bass, and bluegill compete with native fish by preying on invertebrates and small prey fish
8437 (Spurr 2008; West 2009; Arterburn 2014; Park 2014; Froese and Pauly 2018). As a family,
8438 sunfish in the Columbia River Basin can tolerate a wide range of water temperatures 0°C to
8439 32°C (Froese and Pauly 2018).

8440 Walleye (*Sander vitreus*) is a member of the perch family that was introduced to the Pacific
8441 Northwest in the mid-1900s from eastern North America (Sanderson et al. 2009; Froese and
8442 Pauly 2018). Carp, suckers, and sculpins appear to be more important in walleye diets than
8443 juvenile salmon (Zimmerman 1999); however, the walleye population in the Columbia River can
8444 consume as many as 2 million juvenile salmon per year (Rieman et al. 1991; Sanderson et al.
8445 2009). Poe et al. (1991) found juvenile salmonids were the most important prey (27-60 percent
8446 of diet) for walleye less than 300 mm fork length but were frequently of secondary importance
8447 for larger walleye (350mm +). Fish composed nearly 100 percent of walleye diet in The Dalles
8448 and John Day reservoirs (Williams et al. 2019), and salmonid prey items had the greatest
8449 frequency of occurrence in walleye diets than any other prey fish family. Walleye can reach a
8450 maximum size of 42 inches long and 24 pounds (107 cm long and 10.9 kg), with a maximum age
8451 of 29 years (Wydoski and Whitney 2003). According to Caisman (2011), walleye spawn in spring
8452 when the water temperature warms to 3.9°C over a variety of benthic habitats less than 10 feet
8453 (3 m) deep. Walleye mature between 2 and 6 years depending on water temperature and their
8454 density in the waterbody (Lower Columbia Fish Recovery Board 2004a; Schueller et al. 2005;
8455 Caisman 2011). Juvenile walleye initially feed on zooplankton and then switch to benthic
8456 macroinvertebrates prior to becoming piscivorous (Caisman 2011). Juvenile walleye are found
8457 near the surface while adult walleye prefer deeper water (Lower Columbia Fish Recovery Board
8458 2004a) and have diurnal movements, using deep habitats during the day and shallow habitats
8459 at night for feeding (Wydoski and Whitney 2003). Juvenile walleye survival may be limited by
8460 changes in water flows. Increased flows can transport juvenile walleye or their prey to less
8461 advantageous areas (Lower Columbia Fish Recovery Board 2004a).

8462 Historically, walleye were introduced to Lake Roosevelt and have since dispersed throughout
8463 the Columbia River Basin (Caisman 2011) and are established and breeding; suppression efforts

8464 by WDFW and the UCUT tribes are aimed at keeping northern pike from becoming widely
8465 established in Lake Roosevelt. According to Sanderson et al. (2009), anglers in the Columbia
8466 River Basin have caught some of the largest walleye ever recorded at 19 pounds (8.6 kg) in
8467 Oregon (ODFW 2018c) and 20 pounds (9.1 kg) in Washington (WDFW 2018). Reservoirs
8468 associated with dams provide warm water, low currents for juvenile walleye, and deep pools
8469 that benefit adult walleye (Lower Columbia Fish Recovery Board 2004a).

8470 Yellow perch (*Perca flavescens*), introduced from eastern North America in the late 1800s for
8471 fishing and sport fish bait (Harmon 2011), are another perch species well-suited to the reservoir
8472 conditions present in the basin. Yellow perch can tolerate a wide range of water temperatures
8473 0°C to 30°C (Froese and Pauly 2018). Juvenile yellow perch prey include macroinvertebrates
8474 and zooplankton (Froese and Pauly 2018), which reduces prey availability for native fish
8475 (Hughes and Herlihy 2012). Once yellow perch reach three years old, they begin to prey on fish
8476 as well, including juvenile salmon (DePhillip and Berg 1993; Sanderson et al. 2009).

8477 Four non-native pike species (Esociformes order) occur in the Columbia River Basin. Central
8478 mudminnow, northern pike, grass pickerel, and tiger muskie were introduced from eastern
8479 North America (Froese and Pauly 2018; USGS 2018a). Tiger muskies, a hybrid between northern
8480 pike and muskellunge, are stocked in lakes within the Columbia River Basin (USGS 2018a).
8481 Northern pike and grass pickerel are established and breeding in the Columbia River above
8482 Grand Coulee Dam, and grass pickerel are established and breeding in the lower Snake River
8483 (USGS 2018a).

8484 Northern pike (pike; *Esox lucius*) are resident, freshwater fish that inhabit ponds, slow-moving
8485 lakes, and rivers. In the Columbia Basin, they are an invasive species. Pike prefer water
8486 temperatures from 10°C to 28°C (Froese and Pauly 2018) and shallow water with benthic
8487 vegetation to better ambush their prey (Hennessey 2011). Pike are well-known ambush
8488 predators that feed on native fish species and macroinvertebrates (Craig 2008; McMahon and
8489 Bennett 1996). Sepulveda et al. (2013) found that juvenile salmon dominated northern pike
8490 diet when salmon were present; but pike selected other resident fish for consumption when
8491 salmon were not available, thereby impacting both salmon and resident fish. Because of the
8492 strong appetite and prolific spawning capabilities of pike, fisheries managers in Washington are
8493 concerned that, if pike spread from their current range above Grand Coulee Dam into the
8494 Columbia and Snake Rivers below Grand Coulee, they will further endanger ESA-listed salmon
8495 (WDFW 2018g). Because of the concern for resident fish, pike are classified as a prohibited
8496 species in Washington (WDFW 2018b); however, pike are listed as a gamefish in Idaho and
8497 Montana (Idaho Department of Fish and Game [IDFG] 2013; FishMT 2018). Multiple pike
8498 suppression efforts are underway with multiagency funding and support, such as “Northern
8499 Pike Suppression and Monitoring,” the joint project between the Confederated Tribes of the
8500 Colville Reservation, Spokane Tribe of Indians, and WDFW. Additionally, the Columbia River
8501 Inter-Tribal Fish Commission encourages tribal fishers to kill any pike and tiger muskie between
8502 Bonneville Dam and McNary Dam to document species presence in the Columbia River (CRITFC
8503 2018b).

8504 Non-native catfish (Ictaluridae family) occur in the Columbia River Basin and include black
8505 bullhead, channel catfish, brown bullhead, flathead catfish, tadpole madtom, and yellow
8506 bullhead. The four species were introduced from eastern North America (Froese and Pauly
8507 2018; USGS 2018a). Brown bullhead and channel catfish are abundant and reproducing
8508 naturally (WDFW 2018f, 2018g). Black bullhead, flathead catfish, and yellow bullhead are less
8509 common, but present (WDFW 2018e, 2018i; USGS 2018a), while there is little information on
8510 tadpole madtom and blue catfish populations.

8511 Catfish are resident, freshwater fish that live primarily near the bottom of slow-moving lakes
8512 and rivers. As a family, catfish can tolerate a wide range of water 0°C to 37°C and water
8513 conditions (Froese and Pauly 2018). With the exception of the tadpole madtom, of which little
8514 is known, all species are predators of native fish and may reduce native fish and invertebrate
8515 diversity and abundance (Hughes and Herlihy 2012; USGS 2018a). Hughes and Herlihy (2012)
8516 noted that on rivers where non-native species were frequently caught, some historically
8517 present native fish were missing or caught in lower numbers than expected. Channel Catfish
8518 were considered in the original Northern Pikeminnow Management Program (NPMP) studies
8519 but ultimately excluded because, per capita, they constitute a relatively low predation burden
8520 (Poe et al. 1991). Almost all channel catfish predation on juvenile salmonids, characterized in
8521 earlier studies, occurred in tailrace areas and was confined to spring season, likely due to
8522 distribution of channel catfish, which appear to congregate in the upper part of JDA in the
8523 spring.

8524 **Other Non-Native Fish**

8525 Non-native minnow species include common carp, fathead minnow, goldfish, grass carp, and
8526 tench (Froese and Pauly 2018; USGS 2018a). Minnows are resident, freshwater fish in slow-
8527 moving lakes and rivers with dense aquatic vegetation. As a family, minnows can tolerate a
8528 wide range of water temperatures 0°C to 38°C and water conditions including low oxygen and
8529 high turbidity (Froese and Pauly 2018). Non-native minnows feed on zooplankton,
8530 macroinvertebrates, and aquatic vegetation (USGS 2018a). Kaemingk et al. (2016) found
8531 common carp affects native resident fish species by increasing turbidity when it uproots benthic
8532 vegetation while feeding and competes for invertebrate prey. Other minnow species also
8533 increase turbidity and decrease aquatic vegetation when feeding on benthic vegetation (USGS
8534 2018a). Fathead minnow competes with native fish for habitat and food and is a prohibited
8535 species in Washington (Holzman 2014; WDFW 2018d).

8536 Other non-native small fish include brook stickleback (*Culaea inconstans*), banded killifish
8537 (*Fundulus diaphanus*), mosquitofish (*Gambusia affinis*), and goby. These fish have been
8538 introduced into the system through transportation of bait, intentional introductions, or
8539 accidental introductions via ballast water or aquarium trade. These are all small, typically less
8540 than 4 inches (10 cm) long and typically feed on algae, eggs, larvae, and invertebrates. They
8541 provide prey items for piscivorous predators, but also may contribute to the decline of native
8542 species via competition and predation of eggs.

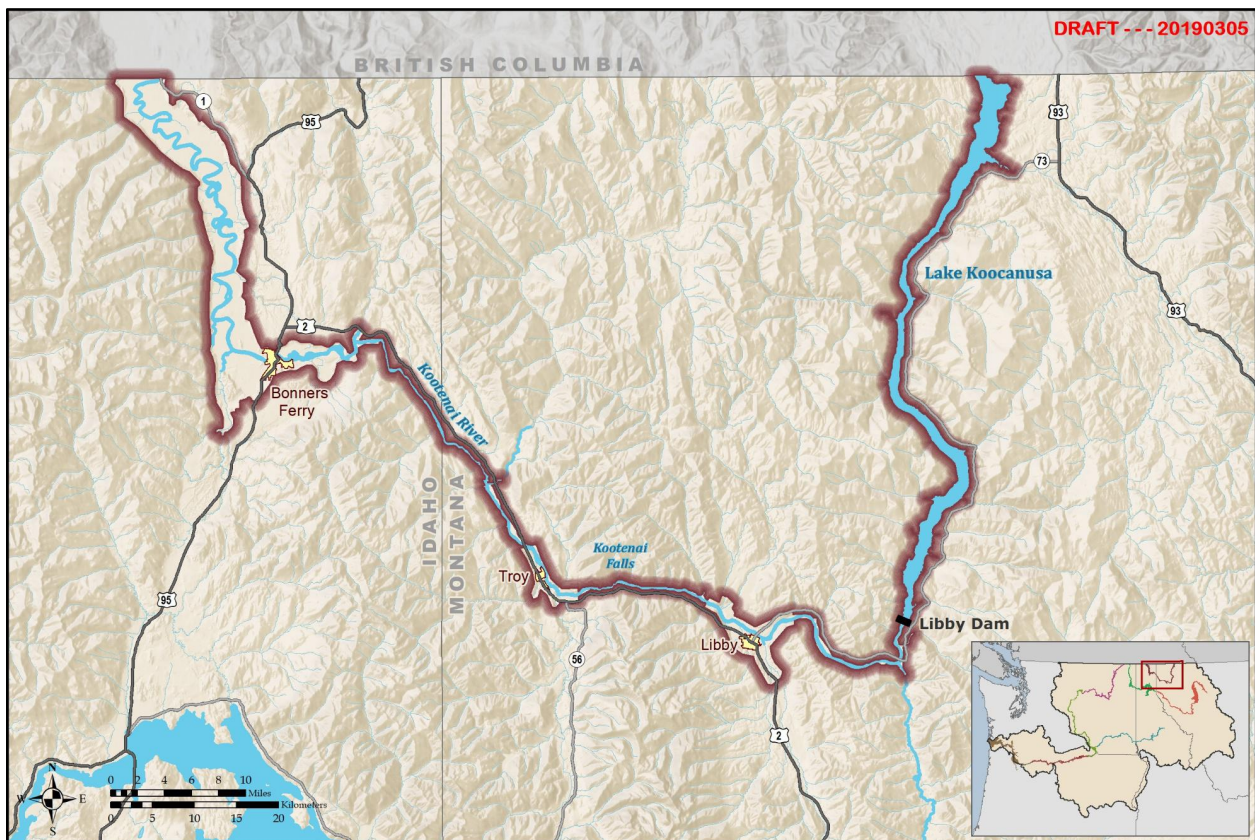
8543 **REGIONAL RESIDENT FISH COMMUNITIES**

8544 This section describes the regional resident fish communities in the Columbia River Basin. The
8545 Basin has been divided into regions based on similar features such as lakes, rivers, streams,
8546 what resources are present, and how they are managed. Resident fish communities can vary by
8547 region because of limited distributions, passage barriers, specialized habitat requirements,
8548 unique life histories, or area of introduction for non-native species. As a result, resident fish
8549 communities are managed on a localized scale as compared to anadromous species. The
8550 previous sections described the life history and requirements for each species, whereas this
8551 section discusses effects to fish communities in each of these regions. The regions are discussed
8552 beginning with the uppermost area of the waterbodies affected by CRS projects and follows the
8553 water downstream to the mouth and estuary of the Columbia River.

8554 **Region A**

8555 ***Kootenai River (Lake Koocanusa to U.S.-Canada Border) Region***

8556 Lake Koocanusa is a reservoir formed by Libby Dam on the Kootenai(y) River (Figure 3-127). It is
8557 a long reservoir (about 90 miles [145 km] long) with about half in Montana and half in British
8558 Columba. Downstream from Libby Dam, the Kootenai(y) River passes over Kootenai Falls 9
8559 miles west of the town of Libby, Montana. The river flows northwesterly through Troy,
8560 Montana, and Bonners Ferry, Idaho, eventually turning north and meandering north to cross
8561 the border back into British Columbia.



8562 **Figure 3-127. Study Area for Kootenai River (Lake Koocanusa to U.S.-Canada Border) Region**
8563

8564 Bull Trout

8565 In the Kootenai River drainage, three distinct populations of bull trout exist: one downstream of
8566 Kootenai Falls, one between the falls and Libby Dam, and one upstream of Libby Dam.

8567 Upstream of Libby Dam, Lake Koocanusa is one of the most secure and stable bull trout refugia
8568 across the range of the species, though most of the spawning and rearing habitat is in British
8569 Columbia (USFWS 2010). Adfluvial bull trout, originating from fluvial stocks in the Kootenai
8570 River that were trapped upstream of Libby Dam, are the only bull trout life history form present
8571 in the lake. Canadian headwaters (Kootenay River tributaries and Wigwam River) are believed
8572 to support the strongest populations (Marotz et al. 2001). Bull trout in Canada are not subject
8573 to protections under the U.S. ESA. The strongest U.S. population upstream of Libby Dam is in
8574 Grave Creek (including Clarence and Blue Sky Creeks) in the Tobacco River drainage with 94 to
8575 245 redds per year counted between 1999 and 2008 (USFWS 2010).

8576 Below Libby Dam, the bull trout population uses four tributaries upstream of Kootenai Falls, but
8577 contains too few individuals and subpopulations to be considered stable. Below Kootenai Falls,
8578 bull trout are found in O'Brien Creek, Callahan Creek and in Bull Lake. The latter is a disjunct
8579 population that migrates out of Bull Lake, downstream to Lake Creek then upstream in Keeler
8580 Creek. These fish inhabit areas in the lower Kootenai River and Kootenay Lake during most of
8581 the year.

8582 Kootenai River White Sturgeon

8583 Approximately 8,000 sturgeon are estimated to have been present in the Kootenai River system
8584 in the late 1970s (Paragamian, Beamesderfer, and Ireland 2005). The wild sturgeon population
8585 declined from approximately 3,000 individuals in 1990 to 990 in 2011 (Beamesderfer et al.
8586 2014a); the current wild population largely consists of an aging generation of large, old fish. The
8587 wild population was found to decline most rapidly from 2008 to 2011 because of decreased
8588 survival rates (97 percent annual survival prior to 2008 and 85 percent from 2007 to 2011),
8589 presumably, because of increased adult age; sturgeon can live more than 80 years. Low levels
8590 of natural recruitment continue, based on low sample numbers of juvenile fish; Beamesderfer
8591 et al. (2014a) estimated natural recruitment (i.e., offspring from spawning, not from hatcheries)
8592 to the wild population of 13 fish per year.

8593 The size and age at which white sturgeon are sexually mature varies, but females are estimated
8594 to begin to be mature at 30 years and males at 28 years (Paragamian, Beamesderfer, and
8595 Ireland 2005). Kootenai River white sturgeon do not spawn each year; females spawn about
8596 every 3 years, while males spawn approximately in alternate years (USFWS 1999). Kootenai
8597 River white sturgeon express a unique, two-step spawning pattern, migrating to staging reaches
8598 from the lower Kootenai River and Kootenay Lake, and then on to spawning reaches near
8599 Bonners Ferry, Idaho, in the spring (Paragamian 2012). The substrate at current spawning sites
8600 in the Kootenai River is much finer than the rocky substrate found in successful white sturgeon
8601 spawning sites elsewhere in the Columbia River Basin.

8602 Spawning in sandy locations may lower survival if sand or silt covers the embryos (McDonald et
8603 al. 2010). It was speculated that prior to the completion of Libby Dam, this area was likely
8604 scoured of sand during high river flows that re-sorted river sediments, providing clean cobble
8605 substrate conducive to egg incubation (USFWS 1999). Research revealed that Kootenai River
8606 white sturgeon are likely spawning in the same locations as pre-dam, but dam operations have
8607 reduced velocities and shear stress; therefore, sediment is now covering the cobbles and
8608 gravels (Paragamian et al. 2009).

8609 White sturgeon are broadcast spawners, which means females typically release eggs over an
8610 area, then males release milt (i.e., sperm) over the eggs to fertilize them (Scott and Crossman
8611 1973; McDonald et al. 2010). Kootenai River white sturgeon spawn when water temperature is
8612 8.5°C to 12°C (McDonald et al. 2010; Paragamian 2012). After fertilization, their eggs adhere to
8613 the riverbed and incubate for 8 to 15 days (Brannon et al. 1985). White sturgeon remain
8614 attached to the yolk after hatching, and they begin to forage as “free embryos” until the yolk is
8615 depleted after about 7 to 11 days (USFWS 2006). At this time, the larval white sturgeon are
8616 distributed by the currents and the juveniles and adults rear in the Kootenai River and in
8617 Kootenay Lake (USFWS 2006).

8618 The Kootenai Tribe’s sturgeon aquaculture program, funded by Bonneville, was established in
8619 1988 to prevent extinction, preserve the gene pool, and continue rebuilding a healthy age class
8620 structure for this endangered population using conservation aquaculture techniques with wild
8621 native broodstock (Kootenai Tribe of Idaho [KTOI] 2012). The wild population of white sturgeon
8622 has been augmented with the release of juvenile white sturgeon reared at the tribal hatcheries
8623 (USFWS 1999). Fish releases continue pursuant to the Kootenai Tribe of Idaho’s USFWS Section
8624 10 permit. Annual releases have ranged from 3,000 to 37,000 fish per year from 2003 to 2013
8625 and with an average annual release of 20,000 fish; from 2008 to 2013, releases have averaged
8626 18,000 fish (Bonneville 2013).

8627 Fish Communities

8628 *Lake Koocanusa (Libby Reservoir)* – The reservoir supports an important fishery for kokanee and
8629 rainbow trout. Burbot are another important gamefish, but their population level has become
8630 severely suppressed, and can no longer provide a fishery. Bull trout serve as an intermittent
8631 (not every year) sport fishery under Section 4(d) of the ESA; when redd counts meet or exceed
8632 established criteria, a limited entry sport fishery is open on the reservoir the following year
8633 (subject to Montana fishing regulations), with anglers allowed to keep one bull trout per year.
8634 Several warm water species such as largemouth bass, pumpkinseed, and yellow perch inhabit
8635 the reservoir but are present only in low numbers compared to other locations where their
8636 populations cause problems for native species. The Gerrard strain of rainbow trout, native to
8637 Kootenay Lake in British Columbia, is cultured at Murray Springs Fish Hatchery by MFWP. This
8638 subspecies attains tremendous size by becoming piscivorous (i.e., eats other fish) at age 2 to
8639 3 years, and has been stocked in the reservoir in increasing numbers since 2006. The average
8640 number of Gerard rainbow trout that MFWP stocked from 2010 to 2012 was 32,000 fish per
8641 year, and the average for 2016 to 2018 was roughly 70,000 per year (MFWP 2018). The

8642 objective for Gerrard rainbow trout in the reservoir is to develop a trophy rainbow trout fishery
8643 as well as provide a natural predator on kokanee; a reduction in kokanee numbers in the
8644 reservoir would likely increase their average size because of less competition for food, and thus
8645 improve the fishery according to angler preference for larger fish. Thus far, the population
8646 structure of Gerrard rainbow trout in the reservoir has yet to achieve the density required to
8647 reduce kokanee densities or to provide growth opportunities for larger, piscivorous individuals.

8648 The upper portion of Koocanusa Reservoir still contains some genetically pure stocks of fluvial
8649 and adfluvial westslope cutthroat trout. In the western United States, however, distribution of
8650 westslope cutthroat trout has declined dramatically from historical levels over the past 30
8651 years, and they now occupy only about 59 percent of lotic (i.e., flowing) habitats of their former
8652 range (Shepard et al. 2005).

8653 *Kootenai River* – The Montana portion of the Kootenai River downstream of Libby Dam
8654 supports a relatively stable and abundant recreational trout fishery of non-native rainbow trout
8655 that account for about 10 to 15 percent of the total fish assemblage according to electrofishing
8656 surveys conducted in 2008 (Gidley 2010). Mountain whitefish are the most abundant fish
8657 species in the Montana portion of the Kootenai River, constituting approximately 60 to 70
8658 percent of the total fish assemblage, but are seldom targeted by anglers (MFWP unpublished
8659 data; Gidley 2010). Since the construction of Libby Dam, the Idaho portion of the mainstem
8660 Kootenai River fish community has shifted from being dominated by whitefish and trout to
8661 consisting primarily of suckers, peamouth chub, and northern pikeminnow.

8662 In the present conditions of Kootenai River, the primary habitat factors limiting resident fish
8663 include an altered hydrograph and riparian condition, elevated turbidity and fine sediments,
8664 reduced connectivity, and an altered thermal regime (Kootenai Tribe and MFWP 2004).
8665 Reduced phosphorus loading to the Kootenai River downstream of Libby Dam limits
8666 productivity of resident fish in this reach (Kootenai Tribe and MFWP 2004). In response to this
8667 limiting factor, the KTOI and the Idaho Department of Fish and Game co-manage the Kootenai
8668 River Ecosystem Improvement Project, which includes nutrient restoration and extensive
8669 monitoring of baseline conditions and the effects of the nutrient restoration. The goal of this
8670 project is a productive, healthy, and biologically diverse Kootenai River ecosystem, with
8671 emphasis on native fish species including white sturgeon, burbot, bull trout, and kokanee.
8672 Preliminary results suggest the project has substantially increased ecosystem productivity in the
8673 nutrient addition zone of the Kootenai River and the South Arm of Kootenay Lake (Holderman
8674 2012).

8675 Burbot had been a valuable sport and commercial fishery in the Kootenai River; however, the
8676 fishery collapsed following the construction of Libby Dam. The fishery peaked in the late 1960s
8677 with over 25,000 burbot harvested annually, and by 1987, none were harvested (Paragamian et
8678 al. 2000). The average abundance estimates for 1997 to 2003 were only 150 to 200 adult
8679 burbot in the Kootenai River (Paragamian et al. 2004). However, a burbot restoration program
8680 including extensive conservation aquaculture was established in 2014 by KTOI and IDFG, in
8681 cooperation with BC. The program is meeting several objectives including the ability to sustain a
8682 harvest fishery, which was re-opened in January of 2019. Current abundance was estimated at
8683 20,000 adults in 2019 (Young, S. and R. Hardy. 2019. KTOI and IDFG, Presentation NW Power

8684 and Conservation Council). Burbot are listed as a species of special concern in Idaho and
8685 Montana.

8686 Native kokanee salmon runs in lower Kootenai River tributaries in Idaho have experienced
8687 significant population declines during the past several decades (Paragamian 1994; Ashley et al.
8688 1997). Adult kokanee in tributaries ranged from about 3,800 to 6,600 fish counted per survey in
8689 the early 1980s and dropped to fewer than 10 counted per survey in the early 2000s (Ericksen
8690 et al. 2009). In the Idaho reach of the Kootenai River, westslope cutthroat trout are not
8691 common and provide only a small portion of the salmonid harvest (Paragamian 1994). Native
8692 interior redband, a subspecies of rainbow trout and designated a species of special concern in
8693 Montana, exist in only a few isolated Kootenai River tributaries (Callahan and Libby Creeks and
8694 tributaries to the Yaak and Fisher Rivers). Mountain whitefish abundance has declined in the
8695 Idaho reach of the Kootenai River since the early 1980s, despite availability of ideal spawning
8696 habitat (Paragamian 1994; Downs 1999). Reduction in productivity of the Kootenai River was
8697 identified as the cause for declining mountain whitefish abundance, so liquid phosphate
8698 fertilizer has been added to the river since 2005 to increase phosphorus concentrations in the
8699 river to pre-dam levels (14,000 to 16,000 fish; Ross et al. 2018). By 2008, the mountain
8700 whitefish population rose to over 17,000 fish and exceeded levels documented in 1980; the
8701 population then dropped below this target in 2014 and 2016, potentially because the
8702 population has reached capacity and has begun to stabilize (Ross et al. 2018).

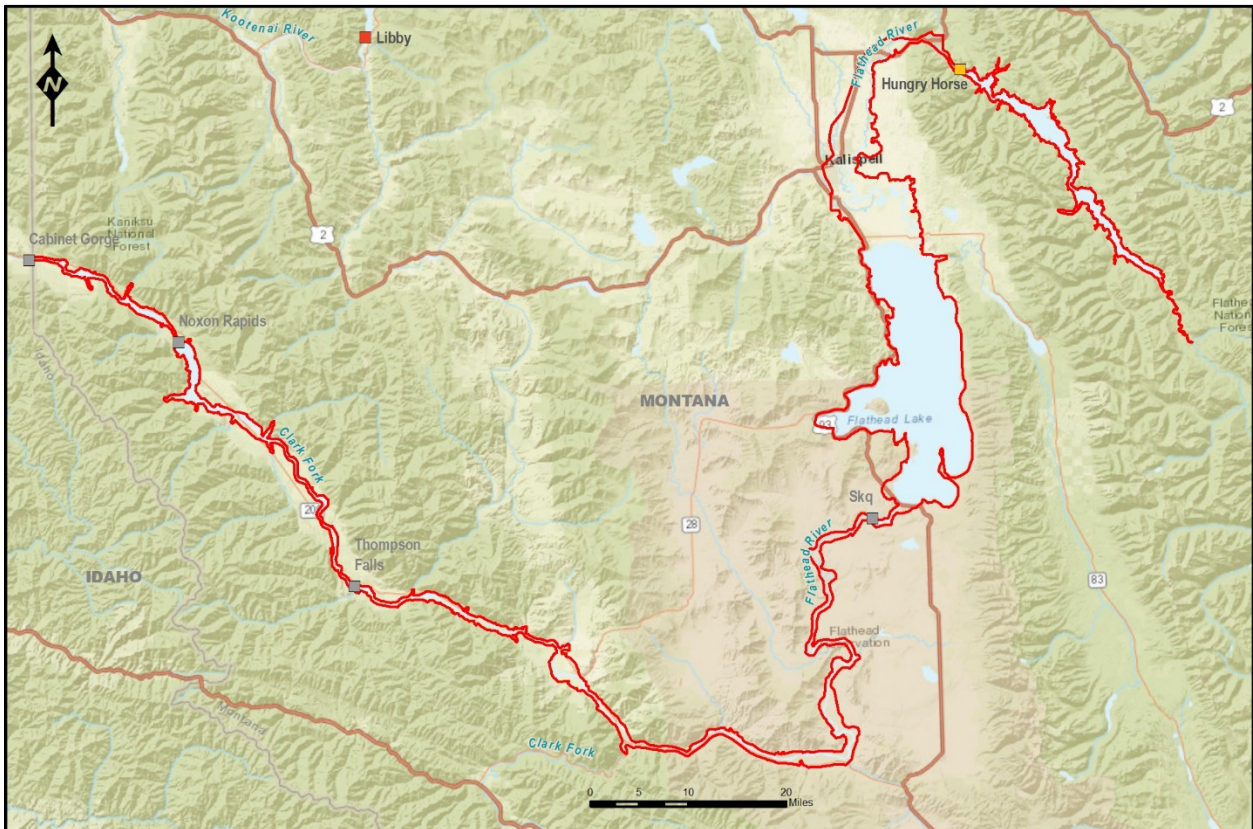
8703 Preliminary important environmental relationships for resident fish in this region that could be
8704 affected by MOs are as follows:

- 8705 • High and prolonged peak flows and the shape of the freshet are important for Kootenai
8706 River white sturgeon spawning. The difference between the winter peak and the spring
8707 freshet are also important for riparian community that supports native fish food supply.
- 8708 • Libby Reservoir temperatures are important to support Kootenai River white sturgeon, bull
8709 trout, and other native fish.
- 8710 • Libby elevation influences discharge temperature in late winter/early spring, with higher
8711 elevations resulting in cooler discharge. Warmer water (10°C) is needed for sturgeon
8712 spawning.
- 8713 • Kootenai River temperatures at Bonners Ferry of 8.5° C to 12° C supports sturgeon
8714 spawning, and an appropriate progression from 2°C to 14°C from mid-February to mid-April
8715 is needed for the biological progression of Kootenai River white sturgeon and burbot
8716 physiology.
- 8717 • Outflow during March through mid-April influences entrainment rates of burbot through
8718 Libby Dam, with higher flows resulting in increased entrainment. For kokanee, entrainment
8719 rates are influenced by outflow in early spring and mid-summer.
- 8720 • River elevation at Bonners Ferry affects floodplain connectivity to off-channel habitats for
8721 burbot and other native fish.
- 8722 • Libby Dam discharge in winter should be low, steady flow, and cold temperature for burbot.
8723 High and variable flows can interrupt spawning.

- 8724 • Libby Reservoir elevation during summer months determines productivity of plankton to
8725 support forage species. In addition, the minimum Libby elevation in one year influences
8726 insect larva production the following year, and the maximum elevation is related to the
8727 volume and surface areas and the proximity of the surface to terrestrial insect production,
8728 which is also important to bull trout food production. This food web is especially important
8729 to bull trout, westslope cutthroat trout, redband rainbow trout, and kokanee.

8730 **Flathead and Clark Fork Rivers from Hungry Horse Reservoir Tributaries to Montana-Idaho**
8731 **Border**

8732 The study area for this region (Figure 3-128) includes from the tributaries to Hungry Horse
8733 Reservoir following the flow of water downstream to where the Clark Fork River flows across
8734 the Montana-Idaho border. Specifically, starting with tributaries of Hungry Horse Reservoir,
8735 water flows through the reservoir, through the dam outlet into South Fork Flathead River,
8736 which then flows into the Flathead River near Columbia Falls. The Flathead River flows
8737 downstream through the Flathead Lake (a large natural lake), past Seli's Ksanka Qlisp'e Dam
8738 (formerly referred to as Kerr Dam) (a non-Federal dam), and joins the Clark Fork River near
8739 Paradise, Montana. The Clark Fork River continues through a series of non-federal hydropower
8740 projects (Thompson Falls, Noxon Rapids, and Cabinet Gorge). The Cabinet Gorge Reservoir pool
8741 is mostly in Montana, with the dam just across the state border in Idaho. This analysis region's
8742 downstream extent is the state border.



8743 **Figure 3-128. Study Area for the Flathead and Clark Fork Rivers from Hungry Horse Reservoir**
8744 **Tributaries to Montana-Idaho Border**
8745

8746 Bull Trout

8747 Hungry Horse Reservoir contains a substantial population of 2,500 to 10,000 adfluvial bull trout
8748 that are stable in number (USFWS 2008a). Hungry Horse is among the most robust and least
8749 threatened populations of bull trout in the recovery area (USFWS 2015). The population is
8750 strong enough to allow for a limited harvest fishery, ongoing since 2004. These bull trout spawn
8751 in the tributaries above Hungry Horse Reservoir and the South Fork Flathead River upstream of
8752 the reservoir. Hungry Horse Reservoir is designated critical habitat for bull trout (75 FR 63898).
8753 Within this area of bull trout habitat, Hungry Horse Dam operations affect reservoir levels and
8754 water temperatures, which influences bull trout habitat and food production.

8755 The South Fork Flathead River below Hungry Horse Dam is only transitional habitat for bull
8756 trout as very few from Hungry Horse Reservoir populations are entrained through the dam
8757 downstream into this reach. Bull trout from the Flathead River wander into this reach
8758 occasionally, but there has been no documentation of spawning by bull trout in this reach. The
8759 few juvenile and subadult bull trout may use this transitory habitat more frequently due to
8760 improved temperatures after the installation and operation of a selective withdrawal-
8761 temperature control device at Hungry Horse Dam. This reach of the South Fork Flathead River is
8762 not designated critical habitat for bull trout.

8763 Flathead Lake adfluvial bull trout reside in Flathead Lake and migrate to spawn in tributaries of
8764 the North Fork and Middle Fork Flathead Rivers, and occasionally in the South Fork Flathead
8765 River. In early summer, adult adfluvial bull trout migrate from Flathead Lake into the river and
8766 move toward staging areas. They then move into spawning tributaries in August, and following
8767 spawning in September, move rapidly (within several days) back downstream to Flathead Lake
8768 (Confederated Salish and Kootenai Tribes [CSKT] and MFWP 2004, as cited in Corps 2006).
8769 Fluvial populations of bull trout spawn and rear in Flathead River tributaries and move
8770 downstream to mature and reside in the Flathead River (CSKT and MFWP 2004, as cited in
8771 Corps 2006). The Flathead River and Flathead Lake are included in designated critical habitat for
8772 bull trout (70 FR 56212).

8773 It is assumed that prior to dams being built on the Clark Fork and the lower Flathead River
8774 supported the Lake Pend Oreille-Clark Fork River bull trout metapopulation and hosted a
8775 considerable migratory component. Today, bull trout exist as relatively isolated populations of
8776 likely less than 100 spawning adults in the Jocko River drainage, and bull trout use the Mission
8777 Creek drainage only as a migratory corridor (CSKT and MFWP 2004, as cited in Corps 2006). Bull
8778 trout found in the lower Flathead River are likely those that were entrained through Seli'sh
8779 Ksanka Qlispe' Dam (formerly Kerr Dam) or upstream migrants from the Clark Fork River.

8780 Thompson Falls, Noxon Rapids, and Cabinet Gorge Dams have a series of impoundments
8781 stretching over 70 miles of the Clark Fork River. These dams were an interruption of bull trout
8782 migration and blocked access from portions of the tributary system to the productive waters of
8783 Lake Pend Oreille and Flathead Lake. However, substantial effort was made to reconnect these
8784 areas. Cabinet Gorge Dam has a trap and haul program that started in 2001, and permanent
8785 passage is expected beginning in 2020 or soon thereafter; Thompson Falls Dam had a fish

8786 ladder installed in 2010; Noxon Dam has a trap and haul program that started in 2017. The
8787 remaining habitat is degraded for bull trout because of water temperature and water quality
8788 (USFWS 2002, as cited in Corps 2006).

8789 The expansion of non-native competitive species such as lake trout, northern pike, and brook
8790 trout, as well as forestry practices, livestock grazing, agricultural water withdrawals,
8791 transportation systems, mining, impoundments, and other development activities have
8792 impacted and continue to affect bull trout in the lower Clark Fork River. Since construction of
8793 the dams that blocked migration routes, the catch of bull trout during gill net surveys in the
8794 reservoirs (between 1960 and 1985) indicates bull trout declined in Noxon Reservoir but
8795 remained somewhat stable in Cabinet Gorge Reservoir (USFWS 2002, as cited in Corps 2006).

8796 In the tributaries of the Clark Fork River, spawning and rearing habitats for bull trout remain,
8797 but foraging, migrating, and overwintering habitats for migratory adult and subadult bull trout
8798 are largely degraded or gone. Over time, the fish expressing the migratory life history pattern
8799 (fluvial and adfluvial) of the lower Clark Fork River were largely replaced by bull trout that
8800 expressed the resident life form in the tributaries, thus reducing genetic diversity and
8801 geographic range (USFWS 2002, as cited in Corps 2006).

8802 Fish Communities

8803 *Hungry Horse Reservoir* – Hungry Horse Reservoir contains primarily native fish species,
8804 including westslope cutthroat trout, mountain whitefish, and bull trout. Hungry Horse Dam has
8805 helped isolate the native fish populations in most of the South Fork Flathead River drainage
8806 from non-native species (such as lake trout), which occur downstream from the dam.
8807 Consequently, the reservoir's population of westslope cutthroat trout is one of the most secure
8808 metapopulations in existence compared to other reservoirs that have a higher number of
8809 introduced species that are competitors or predators (Shepard et al. 2003). Non-game species
8810 include northern pikeminnow, largescale and longnose suckers, and sculpins.

8811 MFWP does not artificially stock the reservoir, and fish populations are maintained solely
8812 through natural spawning and rearing. Westslope cutthroat and bull trout are the most
8813 important game fish species. When sexually mature, these fish migrate to and spawn in the
8814 tributary streams that feed the reservoir, including the South Fork Flathead River upstream of
8815 Hungry Horse Reservoir and its tributaries. Juvenile fish typically rear in these streams for 3
8816 years before they migrate downstream to the reservoir where they grow to maturity. Beginning
8817 in 2004, an experimental bull trout season was initiated that allowed limited (two per year)
8818 angler harvest of bull trout from Hungry Horse Reservoir (CSKT and MFWP 2004).

8819 *South Fork Flathead River* – Most of the fish species in the South Fork Flathead River below
8820 Hungry Horse Dam and the mainstem Flathead River spend a large portion of their life in
8821 Flathead Lake. Native game fish species in the South Fork River and the mainstem Flathead
8822 River include mountain whitefish, westslope cutthroat trout, and bull trout. Non-native species
8823 include lake trout, rainbow trout, lake whitefish, and kokanee.

8824 Since 1995, with operation of the selective withdrawal system and VarQ, releases from the dam
8825 follow a more natural thermal regime approximating conditions in the unregulated reach of the
8826 Flathead River. The observed trend is increasing numbers of native trout, no lake trout, and
8827 very few brook trout, increasing numbers of bull trout and very high numbers of westslope
8828 cutthroat trout. MFWP (personal communication, Brian Marotz 2015) indicated mountain
8829 whitefish numbers have increased since operation of the selective withdrawal system.

8830 Hybridization between rainbow and westslope cutthroat trout is prevalent in the upper
8831 Flathead River. Hybridization, competition, and loss of habitat have contributed to declines of
8832 westslope cutthroat trout, but they are still widely distributed in tributary streams. Westslope
8833 cutthroat trout and bull trout grow to sexual maturity in Flathead Lake and migrate up the
8834 Flathead River to spawn and rear in tributaries. Juvenile cutthroat trout and bull trout leave
8835 rearing streams in early summer and remain in the reach throughout summer and fall as they
8836 move downstream to Flathead Lake. Fluvial populations of cutthroat trout spawn in tributaries
8837 but mature in the mainstem Flathead River without spending time in Flathead Lake.

8838 *Flathead Lake* – Flathead Lake is colder and less productive but with better water quality
8839 compared to most large lakes in the world (CSKT and MFWP 2004, as cited in Corps 2006). The
8840 lake supports native bull trout, westslope cutthroat trout, mountain whitefish, largescale and
8841 longnose suckers, northern pikeminnow, peamouth chub, redbreast shiner, and longnose dace. At
8842 least 11 non-native fish species have been introduced (legally or illegally) into the system since
8843 the late nineteenth century. Historically, bull trout and westslope cutthroat trout were the
8844 dominant piscivorous fishes in Flathead Lake. The introduction of non-native fish, coupled with
8845 the introduction of the non-native opossum shrimp (*Mysis relicta*) in Flathead Lake, has caused
8846 widespread changes in the lake's food web and ecosystem (CSKT and MFWP 2004, as cited in
8847 Corps 2006). Lake trout and northern pike are now the dominant predator fish species in the
8848 lake (CSKT and MFWP 2004, as cited in Corps 2006). Kokanee, once the dominant fish of
8849 Flathead Lake with more than 100,000 spawners in the 1980s, have nearly disappeared such
8850 that no fishery is possible. Westslope cutthroat trout and bull trout populations have declined
8851 as well.

8852 Lake trout (*Salvelinus namaycush*) were introduced in 1905 and are now a primary factor in
8853 reduction of the native salmonid populations in Flathead Lake. The total population grew from
8854 about 2,000 lake trout in 1999 to about 36,000 in 2005 (Hansen et al. 2008); the population is
8855 most recently estimated at nearly 800,000 fish (Hansen, Hansen, and Beauchamp 2016).
8856 Recreational fisheries and lake trout removal by the CSKT are controlling the population, but an
8857 increased fishing effort is needed to enable bull trout recovery (Hansen, Hansen, and
8858 Beauchamp 2016). Other abundant non-native fish species found in Flathead Lake include lake
8859 whitefish, brook trout, and yellow perch.

8860 *Lower Flathead River* – Downstream from Flathead Lake, in the lower Flathead River, prominent
8861 fish species include mountain whitefish, brown trout, rainbow trout, northern pike, largemouth
8862 bass, cutthroat trout, and northern pikeminnow. Introduced species have affected native
8863 species, such as bull trout. Historical operations of Seli's Ksanka Qlispe' Dam inundated

8864 vegetated areas and changed shoreline areas to mud and rock (CSKT and MFWP 2004, as cited
8865 in Corps 2006). However, new minimum flows established by Federal Energy Regulatory
8866 Commission (FERC) relicensing in 1995 have had resulted in stabilized water releases that more
8867 closely approximate the natural flow regime (CSKT and MFWP 2004, as cited in Corps 2006).
8868 These changes are expected to substantially improve habitat conditions for aquatic species on
8869 the lower Flathead River (CSKT and MFWP 2004, as cited in Corps 2006).

8870 *Clark Fork River* – The Clark Fork between Lake Pend Oreille and the Flathead River hosts 29 fish
8871 species. The most common fish are sunfish, yellow perch, northern pikeminnow, shiners,
8872 suckers, and bass (FERC 2000). Salmonid populations in the reservoirs are relatively small yet
8873 self-sustaining and consist primarily of westslope cutthroat trout, rainbow trout, brown trout,
8874 brook trout, bull trout, lake whitefish, and mountain whitefish. The section of the Clark Fork
8875 River from the confluence with the Flathead River downstream at RM 245 passes through
8876 several run-of-river hydroelectric dams at Thompson Falls, Noxon Rapids, and Cabinet Gorge
8877 before flowing into Lake Pend Oreille. Noxon Rapids and Cabinet Gorge Dams were previously
8878 barriers to upstream fish movement at all times of the year, but more recently have had trap
8879 and haul programs. As a result, they have isolated fish populations, selecting against migratory
8880 life histories for westslope cutthroat trout (FERC 2000, as cited in Corps 2006).

8881 The Cabinet Gorge and Noxon Reservoirs are long (10 to 35 miles [16 to 56 km]) and experience
8882 water temperatures that range up to 24°C during the warmest part of the summer. Because of
8883 this, warm and cool water species such as largemouth and smallmouth bass thrive and cold
8884 water fisheries are not present (FERC 2000, as cited in Corps 2006). These projects now support
8885 productive bass fisheries. Attempts at establishing a cold water fishery on the Cabinet Gorge
8886 and Noxon Reservoirs were unsuccessful even with stocking efforts (FERC 2000, as cited in
8887 Corps 2006).

8888 Preliminary important environmental relationships for resident fish in this region that could be
8889 affected by MOs are as follows:

- 8890 • Hungry Horse Reservoir elevations affect primary productivity and zooplankton production
8891 important to the fish community, including those that provide the food source for bull
8892 trout. Higher lake elevations in the warm summer months provide better conditions, and
8893 the maximum elevation draft in a given year affects insect larvae production the following
8894 year with deeper maximum drafts resulting in less food supply. The rate of Hungry Horse
8895 drawdown and refill also affects food production with a gradual rate maximizing
8896 productivity compared to a faster rate.
- 8897 • Hungry Horse Reservoir elevations influence exposure to angling exploitation and
8898 predation, as well as access to spawning areas for bull trout, westslope cutthroat trout, and
8899 other native fish.
- 8900 • Water temperatures affect habitat suitability; the thermal structure of the pool is affected
8901 by the surface elevation.

- 8902 • Entrainment out of Hungry Horse Reservoir is believed to occur to some extent but not
8903 measured; entrainment could change with different outflows.
- 8904 • Within day fluctuations in Hungry Horse Dam outflows and river elevations below the dam
8905 affect productivity in the South Fork Flathead River.
- 8906 • Bull trout and other fish below Hungry Horse Dam can be susceptible to GBT effects if TDG
8907 increases.
- 8908 • The South Fork Flathead River has a more normalized temperature regime that improves
8909 native fish habitat due to selective withdrawal at Hungry Horse outlet; changes in Hungry
8910 Horse Reservoir elevations could reduce the ability to operate selective withdrawal
8911 structures as designed and thereby limit the more normalized temperature regime. Water
8912 temperatures affect the suitability for bull trout and other native fish, as well as the ability
8913 for them to compete with non-native fish.
- 8914 • Minimum instream flows of 400 to 900 cfs (sliding scale) protect habitat in the South Fork
8915 Flathead River.
- 8916 • Higher than normal flows from flow augmentation in summer can decrease suitability of
8917 habitat for native fish; higher flows in winter can hinder establishment of riparian
8918 vegetation and reduce suitability of habitat for native fish.
- 8919 • Increased outflows from Hungry Horse Reservoir increase the effect of lake erosion at the
8920 upper end of Flathead Lake.
- 8921 • Decreased spring peaks in the hydrograph of the Flathead River leads to less frequent
8922 channel maintenance flows; higher and more frequent peaks help maintain habitat for
8923 native fish.
- 8924 • Inflows to Flathead Lake determine lake operations; differing operations could affect fish in
8925 Flathead Lake via temperature changes, entrainment of fish through Seli's Ksanka Qlispe'
8926 Dam (the operating structure for Flathead Lake), and effects to the mysis population that
8927 supports lake trout.
- 8928 • Flows in the Clark Fork River affect the suitability for native fish to compete with non-native
8929 fish such as smallmouth bass and northern pike. Increased flows can increase flushing of
8930 non-native predators. Flows can also affect the ability to run current trap and haul
8931 operations that support bull trout populations.

8932 ***Lake Pend Oreille and Pend Oreille River***

8933 This region includes the Clark Fork River where it flows across the Montana-Idaho border,
8934 through Cabinet Gorge Dam and into Lake Pend Oreille; Lake Pend Oreille and any tributaries
8935 affected by lake operations or used by migratory fish from the lake; and the Pend Oreille River
8936 that flows out of Lake Pend Oreille, through Albeni Falls Dam, and downstream through the
8937 non-Federal Box Canyon and Boundary Dams, and on to the U.S.-Canada border.

8938 Bull Trout

8939 The Lake Pend Oreille subpopulation of bull trout is composed of migratory (fluvial and
8940 adfluvial) fish. It is the largest-known bull trout population in Idaho. Adult and sub-adult bull
8941 trout use Lake Pend Oreille (USFWS 2010). Although considerably reduced from historical
8942 numbers, the population of bull trout in Lake Pend Oreille is considered one of the strongest
8943 populations of bull trout. Meyer et al. (2014) provided an adult population estimate of 12,513
8944 for 2008 for Lake Pend Oreille; the population has appeared relatively steady since 1994. At
8945 least six streams where spawning has been documented are direct tributaries of Lake Pend
8946 Oreille (USFWS 2010a). This combination of productivity and wide distribution amounts to at
8947 least 15 local populations (USFWS 2015b). Redd monitoring in the 7 years following the 1999
8948 listing suggests abundance has increased and the population is stable or increasing.

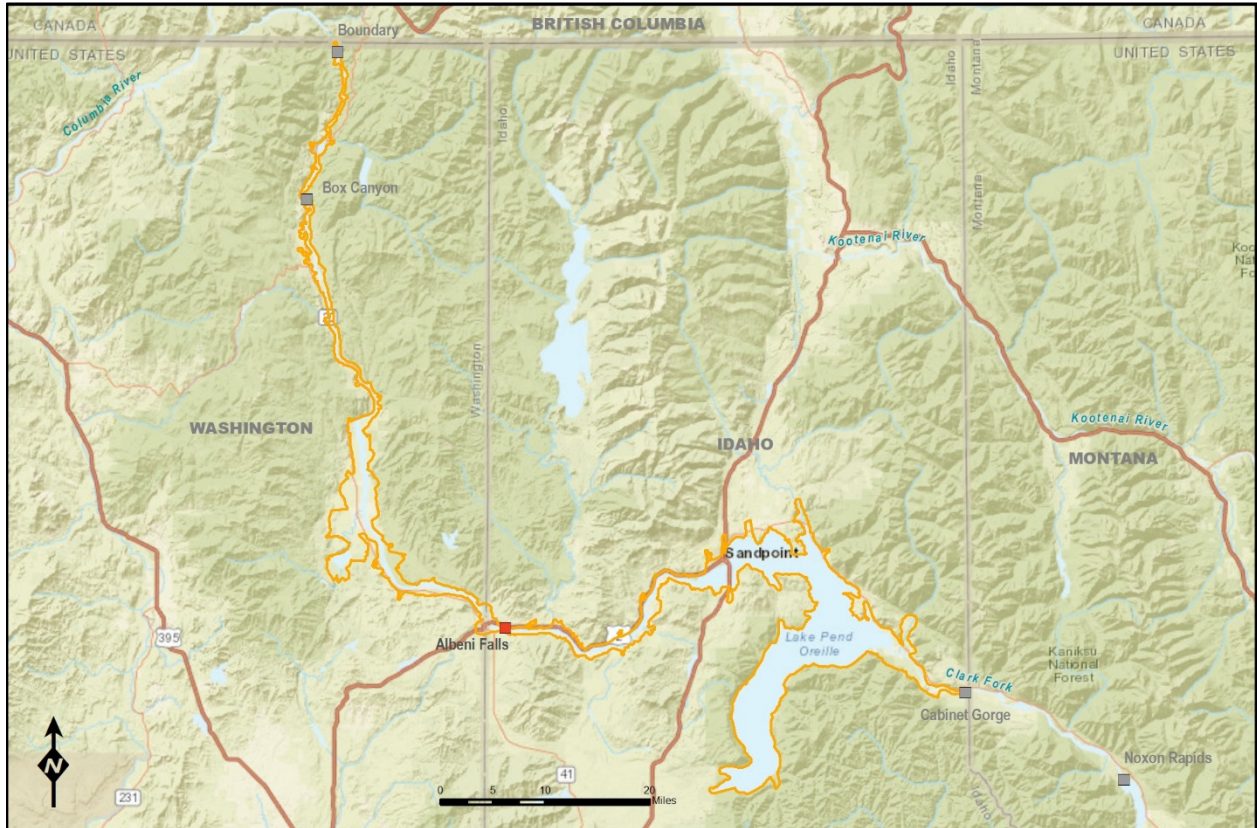
8949 The three dams on the lower Clark Fork River (Thompson Falls, Noxon Rapids, and Cabinet
8950 Gorge) eliminated upstream migration and spawning access from Lake Pend Oreille to 86
8951 percent of the Clark Fork Basin, until 2001 when trap and haul programs began, substantially
8952 reducing the spawning and rearing habitat available for Pend Oreille bull trout (USFWS 2002).

8953 No bull trout spawning has been recorded in lower Pend Oreille River tributaries downstream
8954 of Albeni Falls Dam since 2000, so there are no local populations attributed to this section of
8955 the river. It is likely any prior bull trout populations were extirpated following the construction
8956 of Albeni, Box Canyon, and Boundary Dams, which were built between 1955 and 1967 and
8957 blocked useable habitat for migratory bull trout in the river (USFWS 2002, 2008, 2010a, 2015b).
8958 Migratory bull trout from Lake Pend Oreille, entrained from the Priest River Basin or from Lake
8959 Pend Oreille (the source of bull trout between Albeni Falls Dam and Box Canyon Dam), may use
8960 the river for foraging or refuge during non-summer months. These bull trout may perish if they
8961 cannot be collected below Albeni Falls Dam and released in Lake Pend Oreille (Scholz 2005a,
8962 2005b; Bellgraph et al. 2010).

8963 Historically, adult bull trout have migrated out of Lake Pend Oreille, go down the Pend Oreille
8964 River, and forage in the river from October to June and then return to their tributary streams to
8965 spawn, with the progeny eventually returning to the lake (USFWS 2010). Sub-adult bull trout
8966 and non-spawning adults may remain and rear in the lake year-round (McCubbins and Hansen
8967 2016). Each year, bull trout have potential to be entrained through the Albeni Falls Dam
8968 powerhouse or spillway and prevented from returning to spawn in lake tributaries by the lack
8969 of fish passage facilities at Albeni Falls Dam. USFWS (2018) estimated that around Albeni Falls
8970 Dam, it is likely that a maximum of 50 bull trout may be present above and 50 below at any
8971 time. Recent studies have indicated entrained adfluvial bull trout will not pioneer into
8972 tributaries below the dam and spawn (Geist et al. 2004; Scholz et al. 2005).

8973 Conditions for bull trout habitat and migration in this reach of the study area (Figure 3-129) are
8974 controlled by lack of passage at the dams. Studies indicate bull trout study fish released
8975 downstream of Albeni Falls Dam did not survive through the summer during high water
8976 temperatures in selected years due to lack of thermal refuge (i.e., cold water habitat) below the
8977 dam (Scholz 2005; Bellgraph et al. 2010). Bull trout populations are lower than the natural

8978 carrying capacity due to impassable dams that prevent access of migratory fish to spawning and
8979 rearing areas in headwater areas of tributaries to the Pend Oreille River and Lake Pend Oreille.
8980 Fish passage and bull trout reintroduction efforts are in planning stages for this section of the
8981 Pend Oreille River. Fish passage at Box Canyon Dam below Albeni Falls Dam is set to be
8982 operational in 2020. Construction of a fish trap and haul facility at Albeni Falls Dam may be
8983 constructed during the timeframe of the CRSO analysis period. Bull trout and other salmonid
8984 species that are entrained and pass downstream through the dam likely survive at relatively
8985 high rates that can exceed 95 percent or more (Normandeau 2014).



8986
8987 **Figure 3-129. Study Area for Lake Pend Oreille and Pend Oreille River**

8988 Fish Communities

8989 The Clark Fork River between Cabinet Gorge Dam and Lake Pend Oreille supports cold water
8990 and cool water sport fish. Cold water species including kokanee, rainbow trout, brown trout,
8991 and westslope cutthroat trout are common in the riverine reaches, whereas cool and warm
8992 water species such as yellow perch and largemouth bass are more abundant in the delta region
8993 of Lake Pend Oreille (FERC 2000, as cited in Corps 2006).

8994 *Lake Pend Oreille* – Lake Pend Oreille is home to a wide diversity of catchable species such as
8995 whitefish, cutthroat and brown trout, kokanee, Gerard rainbow trout (also known as
8996 Kamloops), mackinaw or lake trout, large and smallmouth bass, crappie, pumpkinseed sunfish,
8997 perch, and bullhead (catfish). The list goes on with peamouth, northern pikeminnow, tench,

8998 suckers, sculpin, and a variety of smaller minnows contributing to the fish community. Non-
8999 native species have been introduced to Lake Pend Oreille from both legal and illegal planting of
9000 fish in lakes and rivers within the basin, including lake trout and Gerard rainbow trout, which
9001 are popular trophy fisheries. Cold water species (native and non-native) such as trout and
9002 kokanee tend to occupy the deeper waters of the lake, while warm water species such as bass,
9003 perch, crappie, and suckers (most of which are non-native, but some native species can tolerate
9004 warm water) are more prevalent in the nearshore areas and the Pend Oreille River between
9005 Sandpoint and Albeni Falls Dam. The dam provides habitat value, especially to the non-native
9006 warm water species in the summer, by decreasing velocities in the river between the lake and
9007 the dam. Conversely, available habitat for warm water species is adversely affected by the
9008 annual winter drawdown. Water velocities are typically higher and off-channel habitat more
9009 limited during winter lake elevations. Habitat with no velocity disappears as quiet bays and
9010 backwaters are dewatered. Winter drawdown of the lake interrupts spawning or egg incubation
9011 and thereby reduces numbers of non-native species like tench, largemouth bass, pumpkinseed,
9012 and black crappie compared to the population size that would exist if there were no winter
9013 drawdown (DuPont and Bennett 1993).

9014 Kokanee are critical to the fish community in Lake Pend Oreille. Not only do they provide an
9015 important fishery for anglers, they also serve as the primary forage for predatory salmonids,
9016 including ESA-listed bull trout. In 1925, lake trout were introduced to Lake Pend Oreille. These
9017 fish expanded rapidly, competing directly with other predators for kokanee. Mysis shrimp were
9018 introduced in the 1960s to provide additional food resources for kokanee but began competing
9019 directly with kokanee for zooplankton. The combination of predation from lake trout and
9020 competition from mysis nearly caused the collapse of the kokanee population (Corsi et al.
9021 2019). To protect bull trout, no-kill regulations were implemented, and bull trout population
9022 increased by about 6 percent annually from 1996 to 2006 (Hansen et al. 2010). To address the
9023 regional spread of lake trout, several natural resource agencies and the Kalispel Tribe of Indians
9024 used suppression as a management strategy for controlling lake trout populations (Martinez et
9025 al. 2009). Angling and netting combined have removed over 165,000 lake trout from 2006
9026 through 2013, causing a 72 percent decline in juvenile lake trout net catches and a
9027 corresponding increase in the kokanee population (IDFG 2014). Currently, there is a tenuous
9028 balance between predator and prey in Lake Pend Oreille.

9029 *Pend Oreille River* – In the late 1980s, native mountain whitefish, peamouth chub, northern
9030 pikeminnow, and redbreast shiner were the most abundant fish in the Pend Oreille River above
9031 Albeni Falls Dam (DuPont and Bennett 1993). Other native fish include cutthroat trout and
9032 suckers. The Kalispel Tribe of Indians' 2008–2012 electrofishing efforts to capture bull trout
9033 below Albeni Falls Dam provide more current information on species composition and size
9034 ranges of fish within the local area; mountain whitefish had a relatively high abundance at 14 to
9035 33 percent, while bull trout were less than 1 percent in each year (Kalispel Tribe, unpublished
9036 data). Some of these species are lake-dwelling fish such as kokanee, lake whitefish, walleye, and
9037 lake trout. Fish species found downstream of Albeni Falls Dam are similar to those found above
9038 the dam, as fish can be passed downstream through the spillway and powerhouse.

9039 Northern pike have become established in Box Canyon Dam Reservoir and Boundary Dam
9040 Reservoir on the Pend Oreille River where they are considered a serious threat to trout and
9041 other fish species there and throughout the region. Fish surveys conducted in the Box Canyon
9042 reservoir between 2004 and 2011 documented a rapid increase of northern pike in Box Canyon
9043 Reservoir (nearly a hundredfold increase in number of fish captured) and a decline in
9044 abundance (as much as 50 percent drop in catch rate) of forage species such as native minnows
9045 and non-native sunfish, largemouth bass, and yellow perch (WDFW 2013). As of 2018, the
9046 Kalispel Tribe of Indians is effectively reducing the population and has removed approximately
9047 18,000 northern pike from the Pend Oreille River, nearly all of them from the reservoir behind
9048 Box Canyon Dam (NW Council 2018).

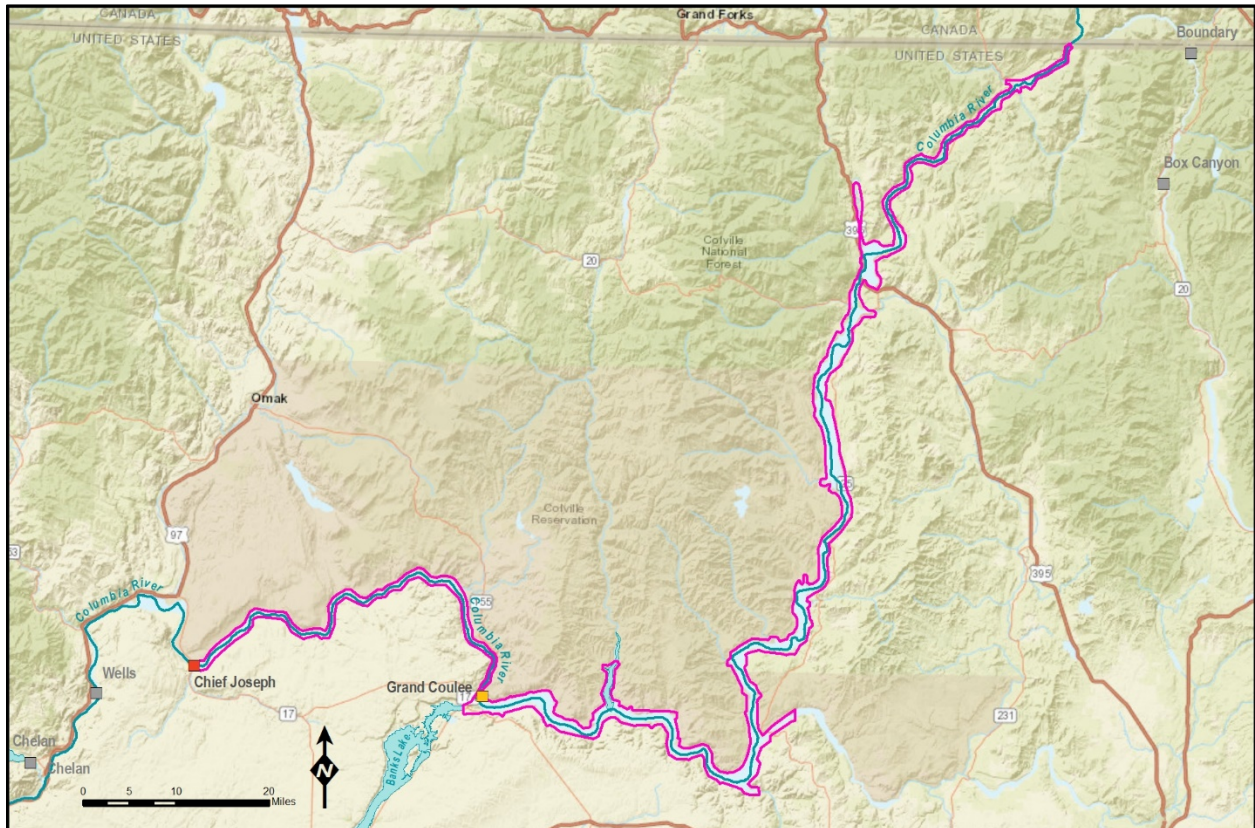
9049 Preliminary important environmental relationships for resident fish in this region that could be
9050 affected by MOs are as follows:

- 9051 • Albeni Falls Dam outflow can affect entrainment rates through the dam. Entrainment can
9052 reduce populations of native fish such as bull trout, westslope cutthroat trout, kokanee,
9053 etc., in the lake as well as hastens the spread of non-native fish from the lake into the river
9054 downstream.
- 9055 • Upstream fish passage at Albeni Falls Dam may be implemented during the timeframe of
9056 the CRSO analysis period.
- 9057 • Predation and competition between non-native and native fish can be influenced by
9058 operations that change outflows, temperatures, and reservoir levels.
- 9059 • Flexible winter power operations result in changing lake elevations in the winter. A greater
9060 range of elevations can increase erosion rates and affect spawning success of kokanee and
9061 mountain whitefish.
- 9062 • Pool elevations affect spawning habitat availability for several species.
- 9063 • Albeni Falls operations affect sedimentation and erosion of lake shorelines, which could
9064 affect the availability of tributary access for bull trout, westslope cutthroat trout, and other
9065 fish that spawn in tributaries.
- 9066 • Kokanee are the main food source for predatory fish such as bull trout in Lake Pend Oreille.
9067 Drawdowns after kokanee spawn can dewater eggs and reduce recruitment, however due
9068 to management guidelines the likelihood of egg dewatering is very low.
- 9069 • Winter flows in the Pend Oreille River can affect spawning success of native fish.
- 9070 • Water temperature in the Pend Oreille River gets too warm for many native fish such as bull
9071 trout, but once entrained, they cannot move back upstream to cooler water.

9072 **Region B**

9073 **Columbia River – U.S.-Canada Border to Chief Joseph Dam**

9074 The Columbia River enters the United States and flows south into Lake Roosevelt, which is
9075 impounded by Grand Coulee Dam (Figure 3-130). Lake Roosevelt extends 151 miles (243 km)
9076 northeast almost to the U.S.-Canada border and impounds the lower reach of the Spokane
9077 River. The next segment between Grand Coulee Dam and Chief Joseph Dam is about 51 miles
9078 (82 km) of impounded pool called Rufus Woods Lake.



9079
9080 **Figure 3-130. Study Area for Columbia River (U.S.-Canada Border to Chief Joseph Dam)**

9081 **Bull Trout**

9082 Fluvial bull trout occur in the Grand Coulee Dam reach, this reach is classified as a research
9083 needs area (USFWS 2015). Since 2011, observations of bull trout have been increasing in Lake
9084 Roosevelt and tributaries in the northern end of the lake, typically in high-flow years (USFWS
9085 2015). In 2012, 19 bull trout observations were reported throughout Lake Roosevelt. These fish
9086 are most likely occasional strays from populations in river systems north of the U.S.-Canada
9087 border (USFWS 2015). The Rufus Woods Lake segment includes the tailrace of Grand Coulee
9088 Dam and the Chief Joseph pool, known as Rufus Woods Lake. This segment of the project reach
9089 lies outside of designated critical habitat for bull trout, and the likelihood of bull trout
9090 occurrence in this waterbody is negligible. Bull trout accounted for less than 0.1 percent of the

9091 catch during the most recent fish inventory of the lake in 1999 (LeClaire 2000; Beeman et al.
9092 2003). Bull trout present in Rufus Woods Lake may have been entrained through Grand Coulee
9093 Dam (Beeman et al. 2003). The Colville Confederated Tribes and the NPCC concluded bull trout
9094 use of Rufus Woods Lake was minimal (Confederated Tribes of the Colville Reservation 2000).
9095 This reach was not included in critical habitat designated in 2010 (50 CFR 17). Bull trout have
9096 been collected in the turbines at Chief Joseph Dam. It is unknown if these fish were entrained
9097 through the turbines or were migrants from the downstream populations that entered through
9098 the draft tubes.

9099 Fish Communities

9100 *Lake Roosevelt (including the Columbia River upstream to the U.S.-Canada border)* – Lake
9101 Roosevelt hosts 15 native and 12 non-native fish species. Lake Roosevelt provides a regionally
9102 and economically important sport fishery; WDFW describes Lake Roosevelt as “Washington’s
9103 biggest summertime playground” due to the robust fisheries for rainbow trout, kokanee,
9104 walleye, smallmouth bass, and burbot (WDFW 2018). Lake Roosevelt also supports an
9105 important population of native redband rainbow trout. All three life history types have also
9106 been documented within the Sanpoil River drainage, including a small fall run of lacustrine
9107 adfluvial fish (Brown et al. 2013). The Sanpoil is the only documented tributary in Lake
9108 Roosevelt supporting fall migrating adult Redband Trout (Jones and McLellan 2018).

9109 Management of the Lake Roosevelt fishery is guided by the Lake Roosevelt Guiding Document
9110 (LRMT 2009) developed by the three co-managers (Colville Tribe, Spokane Tribe, and WDFW),
9111 with a goal to maximize recreational and subsistence harvest opportunities while minimizing
9112 adverse impacts to other native populations.

9113 Primary harvest fisheries include rainbow trout, kokanee salmon, and walleye. The lake
9114 supports popular fisheries and fishing tournaments for trout, walleye, and bass. Other game
9115 fish include yellow perch, lake and mountain whitefish, black crappie, bullhead, sunfish, and
9116 catfish. Non-game species such as suckers, redband shiners, dace, and sculpins provide a prey
9117 base. Bull trout, westslope cutthroat trout, brook trout, and brown trout are encountered but
9118 much less frequently than the key sport fishery species in Lake Roosevelt (Underwood and
9119 Shields 1995; Cichosz et al. 1999). The non-salmonid community, once composed of lamprey,
9120 burbot, white sturgeon, suckers, and native cyprinids such as northern pikeminnow is now
9121 dominated by walleye and smallmouth bass. In addition, mountain whitefish have been
9122 displaced, though not entirely, by lake whitefish (Cichosz et al. 1999).

9123 White sturgeon occur in Lake Roosevelt and the Columbia River upstream from the reservoir.
9124 Following the construction of the Columbia River Treaty Dams in British Columbia, Canada, and
9125 Montana approximately 40 years ago, white sturgeon in the Transboundary Reach of the
9126 Columbia River (Grand Coulee Dam to Hugh Keenleyside Dam) have experienced almost
9127 complete recruitment failure (Hildebrand and Parsley 2013). Thus, the wild population consists
9128 of a few thousand large adults. An international recovery effort was established to address the
9129 declining white sturgeon population in the upper Columbia River. Research and conservation
9130 aquaculture programs were implemented to investigate the lack of natural white sturgeon

9131 production and to restore demographics and preserve genetic diversity. These activities have
9132 determined upper Columbia River white sturgeon spawn annually at two primary locations,
9133 which occur at the confluence of the Pend Oreille and Columbia Rivers below Waneta Dam and
9134 near the town of Northport, Washington, as well as three less substantial sites near Hugh
9135 Keenleyside Dam in British Columbia, and China Bend in Lake Roosevelt. Collectively, this data
9136 suggests the recruitment bottleneck occurs at the stage when larvae are transitioning to natural
9137 foods. There are several hypotheses for the lack of natural recruitment of upper Columbia
9138 white sturgeon including habitat alteration, changes to the hydrograph, increased abundance
9139 of non-native predators, declines in food abundance, and contaminant exposure. Tens of
9140 thousands of white sturgeon larvae are captured each year in upper Lake Roosevelt, and
9141 hatchery produced fish released as yearlings survive well and are transferred to a jointly
9142 managed conservation aquaculture program. This program has experienced tremendous
9143 success, leading to the opening of tribal and recreational fisheries in 2017.

9144 In 1986, the Lake Roosevelt Development Association began a rainbow trout net pen program
9145 to supplement the rainbow trout fishery in Lake Roosevelt (Underwood et al. 2000). Wild
9146 kokanee salmon and rainbow trout fisheries are supplemented through hatchery and net-pen
9147 operations through a multi-agency effort, the Lake Roosevelt Fishery Enhancement Program
9148 (LRFEP). LRFEP is a cooperative effort between the Spokane Tribe of Indians, Colville
9149 Confederated Tribes, WDFW, Eastern Washington University, the Lake Roosevelt Development
9150 Association (now known as the Lake Roosevelt Voluntary Net Pen Program) (Lake Roosevelt
9151 Forum 2011; Reclamation 2009). The purpose of the LRFEP is to develop a collaborative multi-
9152 agency artificial production program to provide a mitigation fishery in Lake Roosevelt.
9153 Investigations suggest the hatchery and net pen programs have enhanced the Lake Roosevelt
9154 fishery while not adversely affecting native stocks within the lake (Lake Roosevelt Forum 2011).

9155 Habitat conditions and the resident fish assemblage of Lake Roosevelt is typical of a reservoir-
9156 based ecosystem that experiences large annual fluctuations (up to 80 ft) in reservoir levels.
9157 Many native fish species such as northern pikeminnow, suckers, chubs, native minnows, and
9158 many of the mussel species endemic to the upper Columbia River have a status of extirpated or
9159 depressed populations because of extreme habitat changes (LRMT 2009). Native fisheries such
9160 as kokanee and redband rainbow trout are sensitive to mechanisms controlled by operations
9161 such as entrainment through Grand Coulee Dam and powerplant, and effects to the food web
9162 based on water travel time through the reservoir.

9163 The non-native and highly invasive northern pike were first observed in Lake Roosevelt in 2011.
9164 The species has been found in Kettle River (NE Washington tributary of the Columbia River)
9165 (<https://www.nwcouncil.org/news/northern-pike-invade-upper-columbia-river>) but has not
9166 currently been documented downstream of Lake Roosevelt. Since that time, northern pike
9167 abundance has increased and their distribution is expanding downstream. The increasing
9168 observations of northern pike in Lake Roosevelt prompted the Lake Roosevelt co-managers to
9169 implement surveys to investigate abundance, diet, growth, origin, spawning locations, and
9170 movement patterns. Aggressive removal plans are underway throughout the reservoir.

9171 *Rufus Woods Lake* – Thirty-three species of fish occur in Rufus Woods Lake, presently or
9172 historically. The fish community includes 19 native species and 12 non-native. Non-native
9173 species include brook trout, brown trout, and rainbow trout. Native species include bridgelip
9174 sucker, sculpin, dace, and mountain whitefish (Hunner and Jones 1996). The major contributors
9175 to Rufus Woods fisheries are walleye, rainbow trout, kokanee, smallmouth bass, lake whitefish,
9176 and burbot. Mountain whitefish support mid-winter tributary fisheries. Kokanee spawn in the
9177 Nespelem River, the largest tributary of Rufus Woods Lake, while a large number of kokanee,
9178 potentially up to 30 percent of stocked fish, are entrained through Grand Coulee Dam (WDFW
9179 2002; LeCaire and Nine 2006).

9180 Because of the steep gradient of this reach (relative to other major rivers and reservoirs in
9181 North America) and narrow canyon morphology, much of the upper reservoir has retained
9182 more riverine characteristics than lower Columbia River reservoirs. Erickson et al. (1977) and
9183 others suggest short water retention times (1.2–4.0 days) in Rufus Woods Lake might limit
9184 plankton and fish production, and thus a major source of fish recruitment in the reservoir may
9185 be young-of-the-year fish (under 1 year old) entrained through Grand Coulee Dam. The fish
9186 community resembles a riverine more than a lake-like fish assemblage.

9187 Entrainment through Grand Coulee Dam from Lake Roosevelt has influenced the fish
9188 assemblage in Rufus Woods Lake. Fish are most likely to be entrained during the spring freshet
9189 and winter drawdown (LeCaire and Nine 2006). The limnetic fish (i.e., fish typically found in
9190 open water away from shore) abundance and distribution compared to monthly entrainment
9191 estimates through Grand Coulee Dam (Baldwin and Polacek 2002), showed that entrainment
9192 varied seasonally; it peaked in late spring and summer then dropped off by fall (Baldwin and
9193 Polacek 2002).

9194 A commercial net-pen rearing operation for rainbow trout exists in Rufus Woods Lake. Some of
9195 these fish escape from the net pen and some are intentionally stocked in the reservoir for a
9196 sport fishery. The rainbow trout fishery is important as a subsistence fishery for members of the
9197 Colville Tribes and a quality sport fishery for non-members. Net-pen released rainbow trout can
9198 be entrained through the dam during higher rates of spill; monitoring of individual rainbow trout
9199 shows high use areas near the forebay and in areas around the net pens (Brown et al. 2012).

9200 High flows during late-spring/early-summer, a common spawning period for many resident
9201 fishes, may flush eggs and larvae from protected rearing areas. Periods of low water levels may
9202 reduce survival of eggs of shallow-spawning species, such as kokanee, and disrupt benthic
9203 invertebrate prey sources (Cushman 1985). In addition, water level fluctuations may affect
9204 shoreline habitat structure such as vegetation abundance.

9205 Preliminary important environmental relationships for resident fish in this region that could be
9206 affected by MOs are as follows:

- 9207 • White sturgeon recruitment success is a function of Columbia River flows at the U.S.-Canada
9208 border greater than 200 kcfs and water temperatures near 14° for three to four weeks in

- 9209 late June and early July, coupled with reservoir elevations low enough to provide adequate
9210 riverine habitat for adequate juvenile development prior to reaching reservoir conditions.
- 9211 • Retention time in Lake Roosevelt is a very important metric for the food web interactions.
9212 Long retention times produce more plankton production that is more evenly distributed
9213 throughout the reservoir; shorter retention times can reduce productivity and also
9214 concentrate the food sources further downstream near the dam. Additionally, retention
9215 time can influence the plankton species composition and size.
- 9216 • Lower retention times that concentrate food further downstream increases entrainment
9217 risk to kokanee, bull trout, redband rainbow trout and other native fish, as well as
9218 potentially increasing the entrainment of non-native predators downstream out of Lake
9219 Roosevelt.
- 9220 • Outflows from Grand Coulee influence the potential entrainment rates of several species.
- 9221 • Reservoir conditions favor non-native predators that affect white sturgeon, burbot,
9222 kokanee, and redband rainbow trout.
- 9223 • Contaminants in the river sediments affect fish, especially sturgeon and burbot, and flows
9224 could influence the risk to these fish if they mobilize more sediment or disperse the
9225 sturgeon larvae where they are more susceptible to exposure.
- 9226 • Reservoir conditions provide rearing habitat for juvenile sturgeon once they get past the
9227 larval stage and for hatchery-reared larvae, as well as burbot.
- 9228 • Reservoir drawdowns in winter and early spring dewater burbot eggs, and if reservoir levels
9229 decrease in September through February kokanee eggs can be dewatered.
- 9230 • Reservoir temperatures affect habitat suitability for fish; kokanee, burbot, and bull trout are
9231 particularly sensitive to warm temperatures.
- 9232 • Northern pike, walleye, and smallmouth bass are non-native predators that thrive in Lake
9233 Roosevelt but can cause predation issues on native fish in the reservoir as well as
9234 downstream in the Columbia River salmon migration corridor.
- 9235 • Reservoir drawdowns in spring can strand adult northern pike, but low water in spring that
9236 allows vegetated shorelines followed by higher elevations creates spawning habitat for
9237 northern pike.
- 9238 • The relationships for westslope cutthroat trout and redband rainbow trout generally also
9239 apply to the resident rainbow trout mitigation fishery (except spawning issues).
- 9240 • Net pens in Lake Roosevelt are susceptible to water quality (temperature, TDG, DO) at the
9241 mouth of the Spokane River.
- 9242 • Reservoir elevations affect the river/reservoir interface into the Spokane arm, which can
9243 affect the rate of freezing. Lower elevations can result in earlier freezing conditions and
9244 necessitate earlier release of net pen fish than is ideal.

- 9245 • Date of initiation of reservoir refill affects release date of net pen fish. Delay of refill
9246 initiation results in either fish being released earlier when they likely encounter more
9247 stressful rearing conditions due to higher temperatures and TDG or releasing fish prior to
9248 refill initiation where they are more susceptible to entrainment due to higher outflows.
- 9249 • Deep drafts of reservoir elevations could limit the ability to launch boats to implement the
9250 northern pike suppression program.

9251 ***Columbia River - Chief Joseph Dam to McNary Dam***

9252 Below Chief Joseph Dam, the Columbia River runs for 149 miles (240 km) through a series of
9253 five narrow reservoirs impounded by run-of-river dams (Wells, Rocky Reach, Rock Island,
9254 Wanapum, and Priest Rapids Dams) constructed and operated by public utility districts (PUDs)
9255 (Figure 3-131). Below Priest Rapids dam there is a free-flowing stretch known as the Hanford
9256 Reach, an approximately 50-mile (80-km) section that extends into the upper portion of
9257 McNary Reservoir.

9258 **Bull Trout**

9259 The entire reach from Chief Joseph Dam to McNary Dam is designated as critical habitat. Major
9260 tributaries within this area with local bull trout populations include the Methow, Entiat,
9261 Wenatchee, Yakima, and Walla Walla Rivers.

9262 Bull trout from the Methow, Entiat, Wenatchee, and Walla Walla Rivers have been documented
9263 using the Columbia River as overwintering and migratory habitat in spring, fall, and winter. Bull
9264 trout from these tributaries have been observed at Rock Island, Rocky Reach, Wells, and
9265 McNary Dams on the Columbia River. Bull trout from the Yakima River have not been found in
9266 the Columbia River.

9267 Subadult and adult bull trout from the Methow River have been found in the Columbia River
9268 from below Rock Island Dam upstream to the Okanogan River Subbasin, while bull trout from
9269 the Entiat River have been documented at Priest Rapids, Wanapum, Rock Island, Rocky Reach,
9270 and Wells Dams on the Columbia River.

9271 Bull trout from the Walla Walla River are still fluvial and have been documented below McNary
9272 Dam and Priest Rapids Dam.



9273
9274 **Figure 3-131. Study Area for Columbia River – Chief Joseph Dam to McNary Dam**

9275 Fish Communities

9276 The reservoirs have relatively undeveloped shoreline and littoral zones (aquatic nearshore
9277 areas) and low water retention time. These two factors are not conducive to a high abundance
9278 of many types of resident fish. Species associated with each reservoir and the unimpounded
9279 Hanford Reach are discussed in their individual sections below.

9280 *Wells Reservoir* – The resident fish assemblage in Wells Reservoir and downstream tailrace is
9281 composed of a diverse community of native and introduced, warm water and cold water, and
9282 recreational and non-recreational fish species. Since the construction of Wells Dam in 1967,
9283 several assessments have either directly or indirectly studied the resident fish assemblage in
9284 the Wells Reservoir (McGee 1979; Douglas County PUD 2008). These assessments have
9285 identified more than 20 species of resident fish including pumpkinseed, rainbow trout, black
9286 crappie, smallmouth bass, mountain whitefish, yellow perch, peamouth, northern pikeminnow,
9287 dace, shiners, suckers, and sculpins (See Resident fish matrix in Appendix E). The resident fish
9288 assemblage in Wells Reservoir is similar to the assemblages in nearby regions, such as Rocky
9289 Reach and Rock Island Reservoirs, and Lake Roosevelt.

9290 *Rocky Reach and Rock Island Reservoirs* – BioAnalysts (2000) identified 41 fish species in the
9291 Rocky Reach Dam area, including cool, cold water, and warm water species. Of the species
9292 identified in this local area, 61 percent are native. The introduced species include brown trout,

9293 brook trout, lake whitefish, Atlantic salmon, pumpkinseed, walleye, yellow perch, and
9294 smallmouth bass. All warm water species in the Rocky Reach area have been introduced. Bull
9295 trout, cutthroat trout, and burbot are rare in the Rocky Reach area (Dell et al. 1975; Burley and
9296 Poe 1994; BioAnalysts 2000), and the number of white sturgeon appears to be quite low (DeVore
9297 et al. 2000). Compared to upstream reservoirs, cooler water temperatures in this local area limit
9298 production of the warm water piscivorous species including smallmouth bass and walleye, and
9299 low turbidity and poor recruitment might limit walleye production (BioAnalysts 2000).

9300 *Priest Rapids and Wanapum Reservoirs* – Within the Priest Rapids Dam area, resident fish
9301 include a diverse mix of native and non-native species, some of which, including smallmouth
9302 bass and walleye, support important sport fisheries; 38 resident fish species occur in the Priest
9303 Rapids project area. Pfeifer et al. (2001, as cited in FERC 2006) indicate most species sampled
9304 were associated with fine substrates and shallow depths; however, some of the more abundant
9305 fish species in the Priest Rapids Dam area are successful in both river and lake habitats. Six
9306 species of native game are present in the Priest Rapids project area including rainbow trout,
9307 cutthroat trout, bull trout, lake and mountain whitefish, and burbot. Of these species, rainbow
9308 trout and mountain whitefish are common throughout the local area, while the other species
9309 are either uncommon or rare.

9310 *Hanford Reach of the Columbia River* – The Hanford Reach extends from the base of Priest
9311 Rapids Dam (RM 393) downstream to the upper portion of McNary Reservoir (Lake Wallula) at
9312 about RM 343. The Hanford Reach is the only un-impounded section of the Columbia River in
9313 Washington above Bonneville Dam, and as such is an important refuge for native resident fish
9314 species. Extensive flow management at upstream dams has created an aquatic environment
9315 subject to substantial water level fluctuations that influence the species composition.

9316 The Hanford Reach has 43 documented fish species, and most are resident species (Gray and
9317 Dauble 1977). Relatively common species include redbreast shiners, carp, largescale suckers,
9318 northern pikeminnow, peamouth, and smallmouth bass. Tench, three-spine sticklebacks, and
9319 mountain whitefish are rarely captured in Hanford Reach. Within the Hanford Reach National
9320 Monument, irrigation-fed ponds and lakes support introduced carp, bass, sunfish, and panfish
9321 (USFWS 2014).

9322 Surveys conducted to evaluate the effects of water level fluctuation on age-0 resident fish
9323 composition, distribution, and abundance in the Hanford Reach indicated resident fish
9324 occurrence is greater in the riverine Hanford Reach compared to the more lake-like
9325 environments of the Columbia River reservoirs (Gadomski and Wagner 2009). This increased
9326 abundance could be attributed to the increased availability of spawning and rearing habitat,
9327 which might mitigate the effects of variable flow regimes.

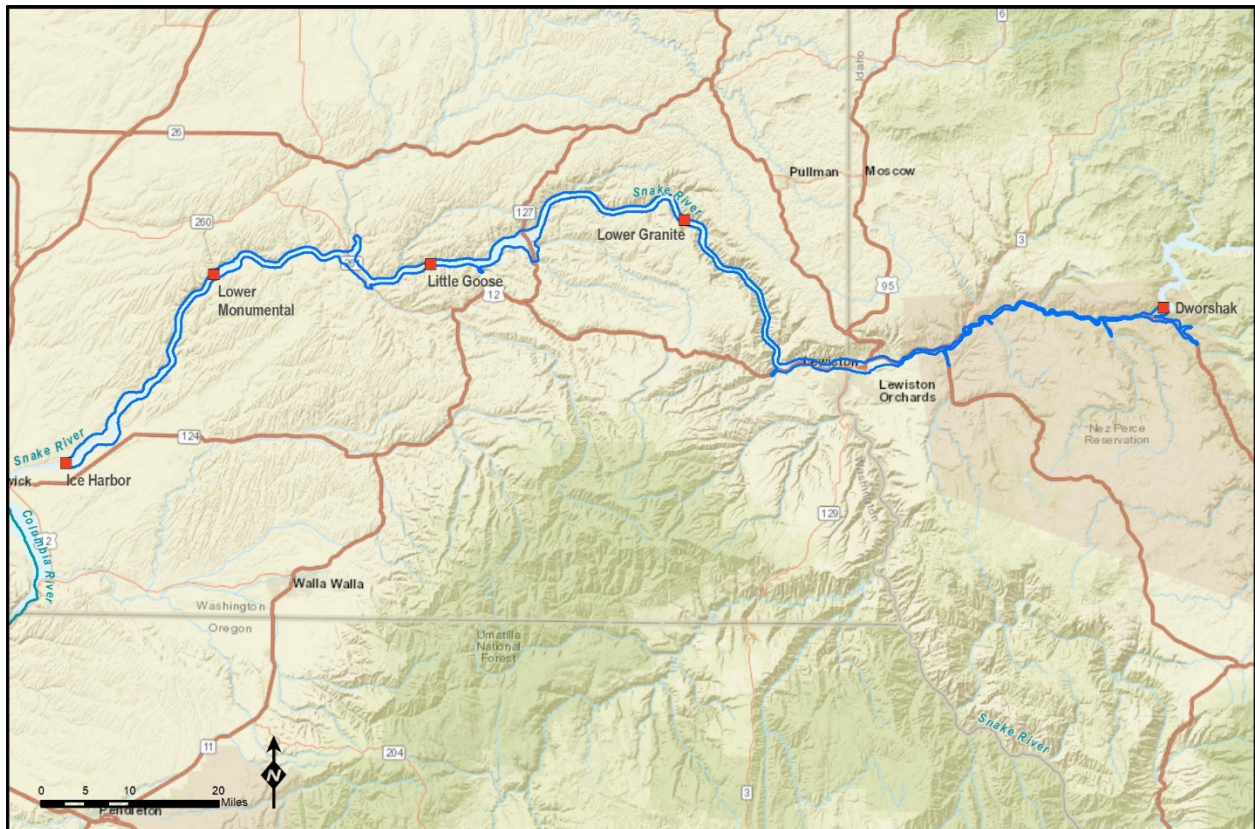
9328 The white sturgeon population in the Hanford Reach is intermediate in size and supports
9329 intermittent spawning, although the frequency at which juveniles reach 1 year of age has not
9330 been measured (Jager et al. 2010). Populations of white sturgeon from the lower Columbia
9331 River up to the McNary impoundment are largely genetically similar despite separation of
9332 population segments by dam construction in the 1950s and 1960s (CRITFC 2011b; Joint

9333 Columbia River Management Staff 2012). There does appear to be some genetic influence on
9334 the mid-Columbia River populations (Bonneville Dam to McNary Reservoir) from upstream
9335 Snake River populations, potentially due to juveniles entering downstream populations (CRITFC
9336 2011b). Harvest from 2001 to 2010 averaged 312 white sturgeon annually, and in 2010, the
9337 fishery above McNary Dam was restricted from year-round to February 1 through July 31
9338 because of concerns for increased harvest levels (Joint Columbia River Management Staff
9339 2012). Subsequently, harvest of white sturgeon above McNary Dam has closed indefinitely.

9340 **Region C**

9341 ***Snake River***

9342 The Snake River Subbasin includes the Snake River from its confluence with the Columbia River
9343 up to Hells Canyon Dam (Figure 3-132). It also includes Dworshak Reservoir and the North Fork
9344 of the Clearwater River down to its confluence with the Clearwater River, the Clearwater River
9345 down to the Snake River, and the Salmon River Basin. Within this subbasin there are five
9346 Columbia River System projects, including one storage dam, Dworshak Dam on the North Fork
9347 Clearwater River, and four run-of-river dams on the Snake River. These include Lower Granite,
9348 Little Goose, Lower Monumental, and Ice Harbor Dams. All four of the lower Snake projects are
9349 equipped with fish passage facilities.



9350 **Figure 3-132. Study Area for the Snake River**
9351

9352 Bull Trout

9353 Adult bull trout that migrate between the lower Snake River reservoirs and tributaries
9354 (*adfluvial*) spend about half of every year in the lower Snake River reservoirs from November to
9355 May. These fish most likely forage in shallow areas where the majority of prey live. Depending
9356 on water conditions, bull trout will occupy deeper areas of the reservoir where water
9357 temperatures are cooler 7.2°C to 12.2°C and move to the surface when water temperatures
9358 drop to or below 12.2°C.

9359 During recent sampling of shallow-water habitats in the lower Snake River reservoirs, single bull
9360 trout have been collected some years at a sampling site in the Lower Tucannon River (Seybold
9361 and Bennett 2010; Arntzen et al. 2012). Researchers speculated this sampling was probably not
9362 indicative of widespread bull trout use of the lower Snake River reservoirs; instead, it is
9363 potentially indicative of an adfluvial life history strategy (Seybold and Bennett 2010). During
9364 sampling and tracking of bull trout in the lower Tucannon River, bull trout have been found to
9365 enter the lower Snake River during October to January, returning to their natal streams from
9366 January to March (Bretz 2011; DeHaan and Bretz 2012).

9367 Adult and subadult bull trout have been detected at all four of the Snake River CRS dams.
9368 Passage at these dams allows genetic exchange between the Walla Walla River, Tucannon
9369 River, Asotin Creek, Grande Ronde River, and Imnaha River Subbasins. The number of bull trout
9370 migrating to the mainstem has been quantitatively estimated in only the Tucannon, Imnaha,
9371 and Walla Walla Subbasins. Bull trout from the Tucannon River have been observed passing
9372 five mainstem dams of which three are downstream (McNary, Ice Harbor, Lower Monumental)
9373 and two are upstream (Little Goose and Lower Granite). Bull trout from the Imnaha River have
9374 been detected passing downstream through Lower Granite and Little Goose Dams and bull
9375 trout from the Walla Walla River have detected moving upstream and downstream through
9376 McNary Dam. There is limited evidence that Asotin Creek bull trout may use areas of Lower
9377 Granite Dam reservoir, and no documented evidence of bull trout from the Clearwater River
9378 entering the mainstem (Barrows et al. 2016). While Dworshak Reservoir and the North Fork
9379 Clearwater River contain healthy populations of bull trout, there is no documented evidence
9380 that these fish regularly reach the Snake River. Likewise, there is no data that bull trout from
9381 the Salmon River Subbasin use the mainstem Snake River for migratory or overwintering
9382 habitat. On the mainstem Snake River, adults tend to move back toward their headwater
9383 spawning area in the spring and summer. Bull trout from the Tucannon River Subbasin enter
9384 the mainstem Snake River from October through February and return from March through July
9385 (Barrows et al. 2016).

9386 Bull trout spawn from August to September during periods of decreasing water temperatures.
9387 Migratory bull trout frequently begin spawning migrations as early as April and move upstream
9388 as far as 155 miles to spawning grounds. Temperature during spawning ranges from 4°C to
9389 11°C, with redds often constructed in stream reaches fed by springs or near other sources of
9390 cold groundwater (Goetz 1989). Water temperatures exceeding 15°C limit bull trout

9391 distribution. Bull trout require spawning substrate consisting of loose, clean gravel relatively
9392 free of fine sediments.

9393 Fish Communities

9394 The Snake River Subbasin contains over 40 resident fish species (Bennett et al. 1983; Bennett et
9395 al. 1991; Mundy and Witty 1998; NPCC 2004a; Seybold and Bennett 2010; Arntzen et al. 2012;
9396 Sholz et al. 2014; Corps 2014). Eighteen of these species are native fish. Some of the more
9397 common fish in the Snake River include bridgelip sucker, smallmouth bass, walleye, peamouth,
9398 and northern pikeminnow.

9399 The Salmon and Clearwater Rivers also provide habitat for resident fish species. Species
9400 composition is similar to those found in the mainstem Snake River, but with fewer warm water
9401 species. Resident fish common in these basins include cutthroat trout, bull trout, rainbow trout,
9402 mountain white fish, sand roller, smallmouth bass, northern pikeminnow, suckers, and in the
9403 lower Salmon Bain, sturgeon. In Dworshak Reservoir, kokanee and smallmouth bass are
9404 important fisheries.

9405 Native cold water resident species (such as trout and whitefish), while not as common in the
9406 lower Snake River, are still abundant in the Clearwater and Salmon River Basins. Their
9407 predominance in the Snake River has been replaced by cool and warm water species (Corps
9408 2014).

9409 Resident fish in the lower Snake River reservoirs occupy numerous habitats and often use
9410 different habitats for different life history stages (Bennett et al. 1983; Bennett and Shrier 1986;
9411 Hjort et al. 1981; Bennett et al. 1991). Warm water species such as small and largemouth bass,
9412 crappie, bluegill, yellow perch, and carp use backwater areas for spawning and rearing (Bennett
9413 et al. 1983; Bennett and Shrier 1986; Hjort et al. 1981; Bennett et al. 1991; Zimmerman and
9414 Rasmussen 1981). Spawning and incubation times vary between species; however, most of
9415 these backwater species spawn from May through mid-July (Corps 1999b).

9416 Juvenile fish occur in abundance in backwater and open-water areas associated with slower
9417 water velocities. Adult distribution is similar to spawning and juvenile distribution, but often
9418 varies depending on feeding strategies of the particular species. Adults may occur throughout
9419 different habitats and move seasonally or daily to different areas (Bennett et al. 1983; Bennett
9420 and Shrier 1986; Hjort et al. 1981). Although adults use a variety of habitat types, lake-dwelling
9421 species are generally more abundant in shallow, slower-velocity backwater areas, and native
9422 riverine species occur abundantly in areas with flowing water found in the tailrace zone (Hjort
9423 et al. 1981; Bennett et al. 1983; Bennett and Shrier 1986; Mullan et al. 1986). Backwater
9424 conditions created by the dams have greatly enhanced nutrient retention (Doyle et al. 2003).

9425 During recent sampling of all four reservoirs in the lower Snake River, studies found smallmouth
9426 bass were the most common predator of the eight predatory species (northern pikeminnow,
9427 smallmouth and largemouth bass, walleye, yellow perch, white and black crappies, and channel
9428 catfish) (Seybold and Bennett 2010). Smallmouth bass were most abundant in Lower Granite

9429 Reservoir, while northern pikeminnow were more abundant at sampling stations downstream
9430 of Lower Granite Dam. Walleye, which were caught only in the Lower Monumental and Ice
9431 Harbor Reservoirs, are now increasingly caught in Little Goose Reservoir.

9432 Preliminary important environmental relationships for resident fish in this region that could be
9433 affected by MOs are as follows:

- 9434 • Bull trout migration into and throughout the main rivers (Snake, Clearwater) for feeding,
9435 migration, and overwintering habitat can be impeded by the project facilities. Bull trout can
9436 be entrained through the Snake River dams with fish tending to move downstream more
9437 readily than upstream.
- 9438 • Water temperatures in Dworshak Reservoir influence the distribution of bull trout; when
9439 further down in the reservoir, they are more susceptible to entrainment.
- 9440 • Generally, warmer temperatures are correlated to higher predation risk to native fish such
9441 as bull trout, redband rainbow trout, etc., to non-native predatory fish.
- 9442 • White sturgeon in the Snake River are very limited in recruitment in this region due to the
9443 limited length of riverine stretch available for larval development between projects. Most
9444 recruitment comes from upstream projects; they generally do not move upstream.
- 9445 • White sturgeon and other fish can sustain physical injury from turbines if they pass through
9446 them.
- 9447 • Reservoir tailraces provide a limited amount of cobble/gravel substrate for rearing habitat
9448 for the yolk-sac larvae of white sturgeon; the rest of the reservoir habitats are very limited
9449 in suitable habitat. This habitat is likely limiting sturgeon recruitment.
- 9450 • Water temperatures in the lower Snake River affect all species. White sturgeon require
9451 temperatures between 8°C and 18°C.
- 9452 • Outflows of Dworshak Dam influence kokanee entrainment susceptibility.
- 9453 • In Dworshak Reservoir, spawning tributaries become inaccessible to spawning kokanee at
9454 an elevation below 1,450 feet in September and October.
- 9455 • Run-of-river reservoir conditions in the Snake River tend to favor predatory fish such as
9456 walleye, smallmouth bass, and pikeminnow with relatively slow, deep, warm water.
- 9457 • Water temperatures and flows affect the production of plankton that form the basis of the
9458 food web to support fish.

9459 **Region D**

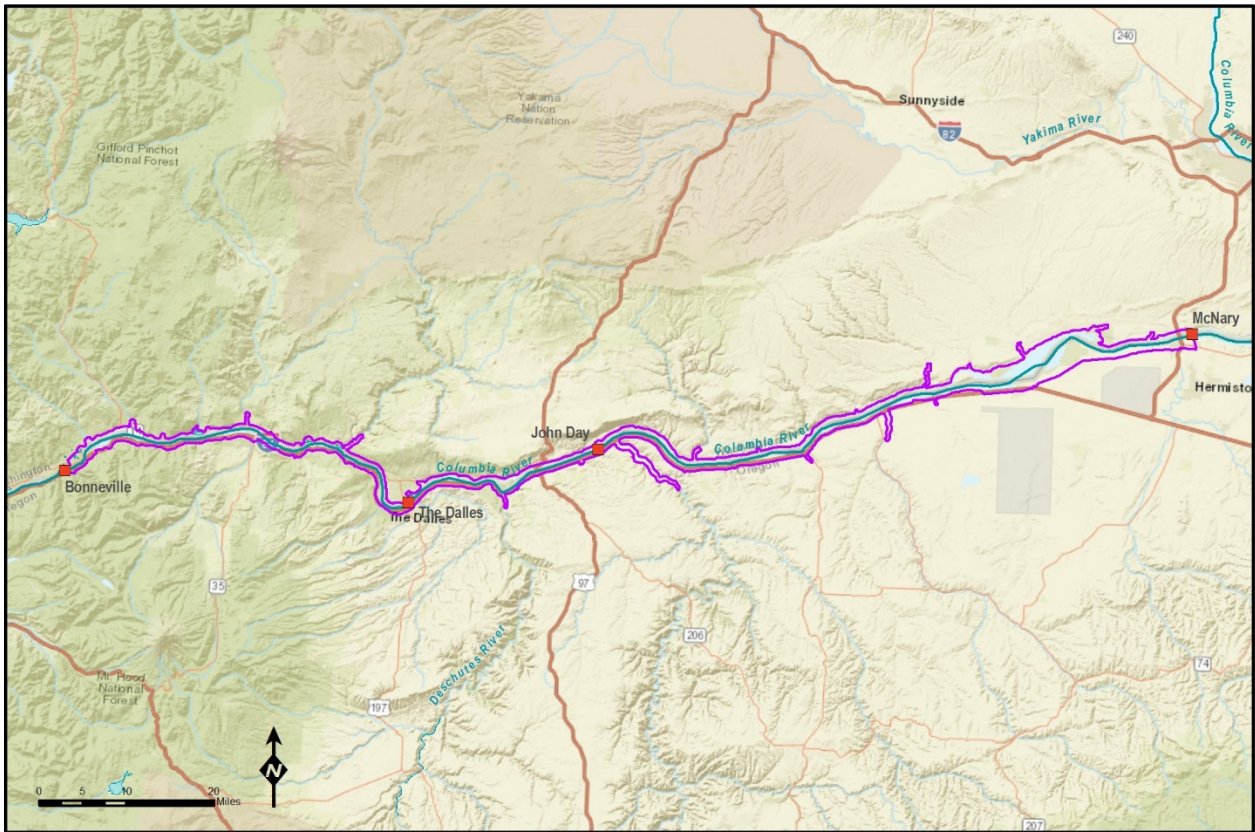
9460 ***Columbia River – McNary Dam to Bonneville Dam***

9461 This region extends for 145.9 river miles from McNary Dam at RM 292.0 downstream to John
9462 Day Dam, The Dalles Dam, and finally Bonneville Dam at RM 146.1 (Figure 3-133). These
9463 projects are run-of-river dams that generate hydroelectric power and are equipped with fish

9464 passage facilities designed for salmonids. Impoundments formed by these dams include Lake
9465 Bonneville, Lake Umatilla, Lake Celilo, and Lake Wallula.

9466 **Bull Trout**

9467 Bull trout have been observed or detected moving upstream at Bonneville Dam and McNary
9468 Dam in the spring and summer (Barrows et al. 2016). The species has been observed or
9469 detected at The Dalles Dam in December and at John Day Dam from April through May.



9470
9471 **Figure 3-133. Study Area for Columbia River – McNary Dam to Bonneville Dam**

9472 **Fish Communities**

9473 At least 45 resident fish species, of which over half are native, have been documented in the
9474 Columbia River between Bonneville and Wanapum Dams (NPPC 2001; Ward et al. 2001). Some
9475 native resident fish (e.g., white sturgeon) use reservoir habitat within this reach of the
9476 Columbia River throughout their life cycle whereas others (e.g., bull trout) live primarily in
9477 tributaries and occasionally use reservoir habitats for foraging or migration (NPPC 2001). Within
9478 this reach of the lower to middle Columbia River, the mainstem dams are barriers to upstream
9479 movements by most resident fish. However, white sturgeon (Warren and Beckman 1989) and
9480 other residents including bull trout are known to pass through fishways at the dams, although
9481 in very low numbers. The degree of entrainment of resident fish downstream through

9482 Bonneville and The Dalles Dams is largely unknown (NPPC 2001). Resident piscivores in this
9483 reach of the Columbia River include northern pikeminnow, smallmouth bass, and walleye.

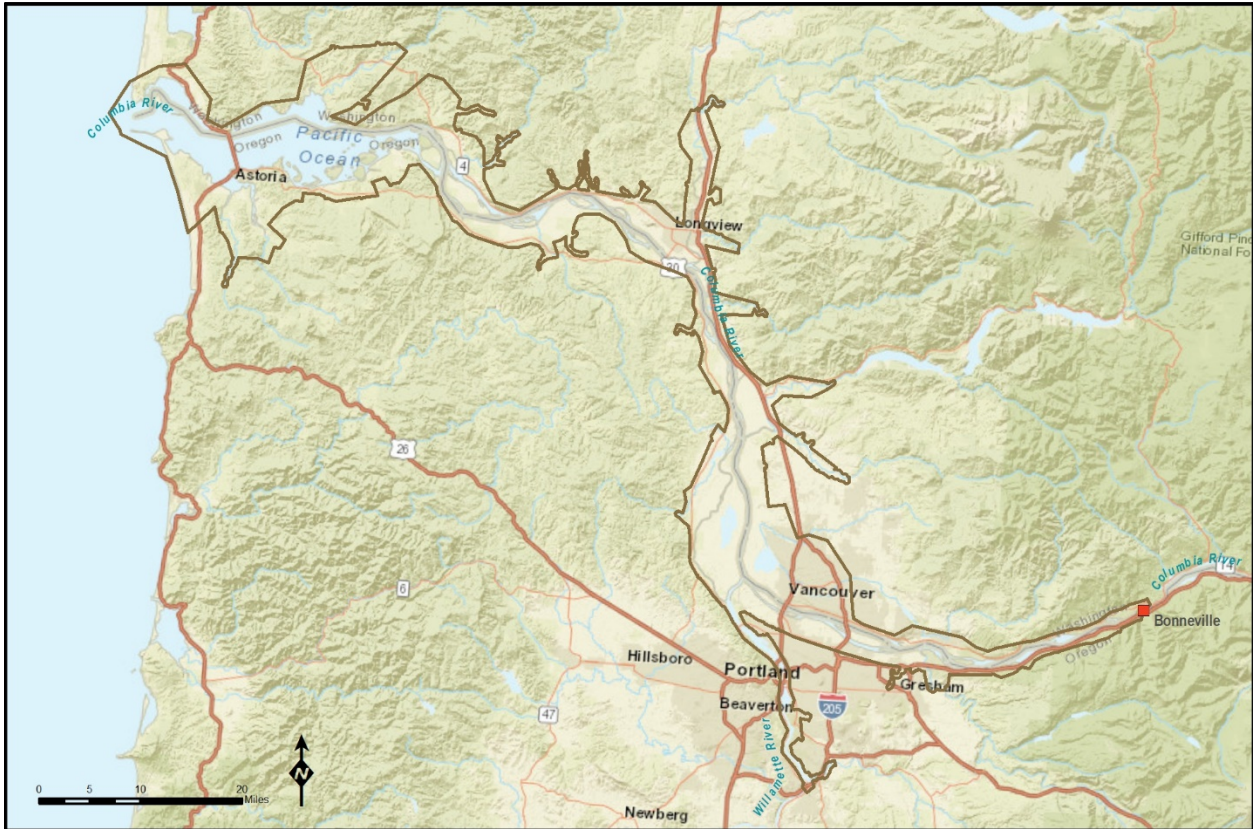
9484 The Corps has identified legacy contamination on and around Bradford Island in the Bonneville
9485 Lock and Dam Project. The Corps has published results of sampling sediment, clams, and fish
9486 tissue. Elevated levels of PCBs were found in smallmouth bass. The Corps continues to
9487 investigate potential clean up options.

9488 Hjort et al. sampled lower Columbia River reservoirs in 1981 for resident fish and observed
9489 several species of resident minnows. They found mountain whitefish, largescale sucker,
9490 bridgelip sucker, peamouth, and redbase shiner in Lake Bonneville. Bridgelip sucker,
9491 chiselmouth, redbase shiner, sand roller, longnose dace, peamouth, and largescale sucker were
9492 found in Lake Umatilla, and Lake Celilo contained longnose dace, peamouth, chiselmouth,
9493 largescale sucker, and bridgelip sucker (Hjort et al. 1981).

9494 Preliminary important environmental relationships for resident fish in this region that could be
9495 affected by MOs are as follows:

- 9496 • White sturgeon recruitment is correlated with flows greater than 250 kcfs from McNary
9497 Dam when temperatures are between 10°C and 18°C.
- 9498 • White sturgeon larvae need substrate with small spaces between gravel for growth and
9499 survival of yolk-sac larvae. The magnitude and duration of high spring flows affects this
9500 habitat.
- 9501 • White sturgeon and other species can be affected by high levels of TDG.
- 9502 • Project facilities can impede the upstream migration of white sturgeon and bull trout that
9503 typically rely on migration and can result in isolated populations. Project configurations and
9504 operations can influence factors that increase or decrease risk.
- 9505 • Bull trout and white sturgeon can migrate downstream through turbines, where they are
9506 susceptible to injury or mortality. Operations of projects can influence factors that increase
9507 or decrease risk.
- 9508 • Access to thermal refugia is important to bull trout and other species.
- 9509 • Fluctuations in pool elevation in the Bonneville Reservoir can suppress vegetation on the
9510 delta at the mouth of the Klickitat and Hood Rivers. This can make bull trout subject to
9511 predation when using this area.
- 9512 • Reservoir conditions typically favor non-native fish such as walleye and smallmouth bass, as
9513 well as predatory pikeminnow; changes in operations, outflows, and reservoir levels can
9514 affect success of these fish.
- 9515 • The presence and abundance of shad can subsidize the diets of predatory fish to increase
9516 their survival, and then when the shad are gone, the predators switch to native fish such as
9517 juvenile migrating salmonids.

9518 **Columbia River – Below Bonneville Dam**



9519
9520 **Figure 3-134. Study Area for Columbia River – Below Bonneville Dam**

9521 **Bull Trout**

9522 Bull trout found below Bonneville Dam include fish from the Lewis, Hood, and Klickitat Rivers.
9523 The only basin that contains bull trout below Bonneville Dam is the Lewis River. Lewis River bull
9524 trout could be present in the mainstem Columbia River downstream from Bonneville Dam, but
9525 the three Lewis River dams and reservoirs restrict downstream movement and it is likely that
9526 very few individuals are able to migrate to the Columbia River.

9527 Limited data for bull trout at Bonneville Dam and within Lake Bonneville suggest downstream
9528 movement from Hood River potentially occurs throughout the year. Bull trout intending to
9529 return to the Hood River from downstream of Bonneville Dam must pass upstream via one of
9530 several fish ladders. Only one PIT-tagged bull trout has been detected moving upstream
9531 through the fish ladders at Bonneville Dam. The detection history of this fish suggested it
9532 passed upstream through the ladder without being delayed and subsequently returned to the
9533 Hood River Subbasin.

9534 **3.5.2.5 Aquatic Macroinvertebrates**

9535 The Columbia River Basin is diverse in native aquatic macroinvertebrates. Although there is
9536 little information on the basinwide number and type of native aquatic macroinvertebrates

9537 inhabiting the study area, their importance has been well established through ecological
9538 studies. These benthic (bottom-dwelling) macroinvertebrates of river and reservoir habitats
9539 occupy habitats according to several parameters such as flow velocity, depth, temperature, and
9540 substrate types. They can serve as indicators of the overall integrity of an ecosystem and
9541 presence or absence of pollutants. Benthic organisms contribute vitally to the diets of fish, bird,
9542 and amphibian species. Freshwater aquatic macroinvertebrates provide energy transfer from
9543 detritus and algae to salmon and trout in the Columbia River Basin (Cederholm et al. 2000).
9544 Types of aquatic macroinvertebrates include insects, worms, and mollusks, and they are
9545 described in the following subsections according to whether they are native or non-native.

9546 **NATIVE AQUATIC MACROINVERTEBRATES**

9547 Native aquatic insects and worms are not well studied in the study area. According to
9548 BioAnalysts (2006), aquatic insect and worm taxa richness increased when more diverse habitat
9549 (e.g., vegetation, substrate) was present.

9550 The five orders of aquatic insects most important to aquatic ecosystems in the study area are
9551 stoneflies (Plecoptera), mayflies (Ephemeroptera), caddisflies (Trichoptera), the aquatic beetles
9552 (Coleoptera), and many species of true flies (Diptera). Many insects lay their eggs in water, with
9553 early life stages (larvae) residing primarily on or associated with the river or reservoir bottom
9554 after hatching. They are important to aquatic ecosystems because they serve as food for many
9555 species and for the roles they play in nutrient cycling and detritus processing. Aquatic insects
9556 are classified into several functional categories including shredders (e.g., giant stoneflies),
9557 scrapers (e.g., case-maker caddisflies), and collector-gathers (e.g., minnow mayflies) based on
9558 feeding habits (Cummins and Klug 1979; Merritt and Cummins 1984). Food requirements can
9559 determine aquatic insect location and abundance in the study area (Cederholm et al. 2000).

9560 Large aquatic insects, such as caddisflies, feed on larger organic particles and inhabit cooler
9561 water, while small aquatic invertebrates, such as *Daphnia* and other zooplankton, feed on fine
9562 organic particles and inhabit slow-moving water (Rondorf, Gray, and Fiarley 1990; Cederholm et
9563 al. 2000). Aquatic macroinvertebrates are important for nutrient recycling, in part because the
9564 macroinvertebrates break down dead organic matter, such as adult salmon carcasses and non-
9565 viable salmon eggs and fry, and then serve as food for juvenile salmon and resident fish
9566 (Rondorf, Gray, and Fiarley 1990; Cederholm et al. 2000).

9567 In reservoirs, larger, long-lived species dominate the permanently wetted zone, whereas the
9568 varial zone contains mainly small, short-lived species. Larvae recolonize previously dewatered
9569 substrates as the reservoir fills, and shoreline areas are dominated by dipterans (flies) that
9570 produce cohorts throughout the warm summer months (Chisholm et al. 1989). Zooplankton are
9571 an important food source to fish in deep reservoirs. As benthic production may be constrained
9572 by water-level fluctuations, planktonic communities can be very productive and abundant in
9573 the euphotic zone of these waterbodies.

9574 Along the length of the rivers that have been impounded, the prey base has changed since the
9575 construction of the dams, shifting from dominance of benthic organisms to dominance of open-
9576 water zooplankton. Benthic diversity in the lower Snake River reservoirs is relatively low and is

9577 dominated by midges and worms. The density of other taxa such as amphipods (*Corophium* sp.)
9578 and nematodes is also low. Mollusk diversity is substantially lower since the impoundment of the
9579 Snake River from over 30 mollusk species to just 7 (Frest and Johannes 1992). However, crayfish
9580 appear to be well established along rock substrate and riprap in the lower Snake River reservoirs;
9581 they provide an important food source for several fish species including northern pikeminnow,
9582 white sturgeon, channel catfish, and smallmouth bass, but not for juvenile salmonids.

9583 Native, freshwater mollusks include clams, mussels, snails, and limpets (Adams 2003). Their
9584 importance in the Columbia River Basin comes from their ecosystem functions, and some
9585 species have cultural importance as food. Freshwater mollusks filter algae, bacteria, and
9586 plankton from water, and then expel unneeded materials, which becomes food for aquatic
9587 insects (Nedeau et al. 2009). Mussels stir benthic sediments, releasing nutrients and providing
9588 habitat for insect larvae for adherence to a substrate (Nedeau et al. 2009). Mollusks are also an
9589 important food source for mammals such as otters and raccoons (Nedeau et al. 2009).

9590 The California floater mussel (*Anodonta californiensis*) and Columbia pebblesnail (*Fluminicola*
9591 *fuscus*) live in the Columbia River Basin (Oregon Biodiversity Information Center 2016).
9592 Freshwater mussels, such as the California floater, are long-lived and rely on fish as an
9593 intermediate host between the larval and juvenile mussel stages (Nedeau et al. 2009). Their life
9594 histories and habitat requirements are not well-known (Nedeau et al. 2009). According to Nedeau
9595 et al. (2009), three-quarters of the freshwater mussels in North America are in danger of
9596 becoming extinct and up to 35 species are possibly extinct. California floaters can live to 100 years
9597 old and prefer clear waterbodies with soft substrate (Pacific Biodiversity Institute 2018a). The
9598 Columbia pebblesnail is short-lived and prefers clear, cold streams (Pacific Biodiversity Institute
9599 2018b). Little is known about other freshwater mollusk species in the Columbia River Basin.

9600 **NON-NATIVE AQUATIC MACROINVERTEBRATES**

9601 USGS lists 52 macroinvertebrates in the Columbia River Basin and coastal waters off Oregon
9602 and Washington as non-native aquatic species (USGS 2018a). Of these species, 30 invertebrates
9603 occur in the study area including copepods, gastropods, crayfish, amphipods, isopods, and one
9604 shrimp species, to name a few. Asian clam (*Corbicula fluminea*), New Zealand mudsnail
9605 (*Potamopyrgus antipodarum*), Siberian prawn (*Exopalaemon modestus*), and the copepod
9606 (*Pseudodiaptomus forbesi*) are widespread within the Columbia River Basin (USGS 2018a).
9607 Introduced (non-native) species can occasionally become invasive if there are no natural
9608 controls on their populations such as predators, lack of food, or harsh climate conditions.
9609 Established aquatic invasive macroinvertebrates tolerate high temperatures, increased
9610 turbidity, and slow water found in Columbia River System reservoirs (USGS 2018a).

9611 Asian clam, Chinese mitten crab (*Eriocheir sinensis*), and New Zealand mudsnail primarily affect
9612 infrastructure (USGS 2018a). Asian clams and New Zealand mudsnails can clog pipes, while
9613 Chinese mitten crabs may destabilize banks or levees (USGS 2018a). Established aquatic
9614 invasive macroinvertebrates tolerate high temperatures, increased turbidity, and slow water
9615 found in Columbia River System reservoirs (USGS 2018a).

9616 The Japanese fishlouse (*Argulus japonicus*), Chinese mitten crab, Northern crayfish (*Faxonius*
9617 *virilis*), and New Zealand mudsnail are the species with the greatest potential impact to native
9618 species in the study area (USGS 2018a). Japanese fishlouse parasitize native resident fish and
9619 affect feeding and growth (USGS 2018a). New Zealand mudsnails outcompete other benthic
9620 macroinvertebrates for space and food (USGS 2018a). Chinese mitten crabs and Northern
9621 crayfish outcompete native crabs for food and space. Northern crayfish increase turbidity,
9622 which can prevent native species from thriving (USGS 2018a). Other non-native
9623 macroinvertebrate species do not appear to interact with native species.

9624 Siberian freshwater shrimp (or prawn; *Exopalaemon modestus*) were discovered in the lower
9625 Columbia River in 1995 and have since expanded to the lower Snake River reservoirs (Emmett
9626 et al. 2002; Erhardt and Tiffan 2016). The effects of the Siberian prawn on the Columbia River
9627 System have not been fully studied yet, but this species may compete with juvenile salmon by
9628 preying on native amphipods or by providing a food source for resident fish that consume
9629 salmon such as smallmouth bass, northern pikeminnow, or walleye (Haskell et al. 2006;
9630 Sanderson et al. 2009). The Siberian prawn diet contains a large percentage of opossum shrimp
9631 (*Neomysis mercedis*), which are native to the brackish lower Columbia River and can occupy
9632 freshwater lakes and slow-moving rivers (Haskell and Stanford 2006).

9633 The opossum shrimp range has expanded 430 miles upstream from the mouth of the Columbia
9634 to the Lower Granite Reservoir in the Snake River; within the Columbia and Snake Rivers, their
9635 abundance is limited in areas with high water velocity (Haskell and Stanford 2006; Tiffan et al.
9636 2017). The range expansion of opossum shrimp may have aided the establishment of Siberian
9637 prawn by providing a steady food source; in addition, opossum shrimp are consumed by fish
9638 such as smallmouth bass, a predator of juvenile salmon (Erhardt and Tiffan 2016; Tiffan et al.
9639 2017). Opossum shrimp are omnivorous, and their diet consists of several species of
9640 zooplankton and what is likely detritus (organic particulate matter) from the river bottom
9641 (Tiffan et al. 2017). Although diet overlap may create competition for zooplankton between
9642 opossum shrimp and juvenile salmon, opossum shrimp can be a prey source for juvenile salmon
9643 (Tiffan, Erhardt, and St. John 2014; Tiffan et al. 2017). More information is needed to fully
9644 describe the food web effects of opossum shrimp (Tiffan, Erhardt, and St. John 2014).

9645 Two macroinvertebrates that are not found in the Columbia River Basin but occur in adjacent
9646 watersheds are the zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena*
9647 *rostriformis bugensis*) (USGS 2018a). Both species are of great concern because these species
9648 have become invasive; they clog water infrastructure pipes and grow out of control (USGS
9649 2018a).

9650 In 2014, the NPCC created a plan for fish and wildlife to help detect the presence of aquatic
9651 invasive species (NPCC 2014). The Council and its partners are monitoring for the presence of
9652 aquatic invasive species and are assisting with public education outreach to help educate
9653 stakeholders about the threats of aquatic invasive species to native species and aquatic
9654 ecosystems. The states of Idaho, Montana, Oregon, and, Washington have aquatic invasive
9655 species detection programs that include mandatory watercraft inspection stations located at

9656 strategic locations along or near state borders. Additionally, the states are monitoring for
9657 presence of these species and providing public education programs (Idaho.gov 2018;
9658 Montana.gov 2018; Oregon.gov. 2018; WDFW 2018).

9659 **3.5.3 Environmental Consequences**

9660 Operation, maintenance, and configuration of the CRS affect fish and aquatic habitat in multiple
9661 ways. Anadromous fish traveling to and from the ocean pass dams and reservoirs with passage
9662 both upstream and downstream, while resident fish may pass dams and reservoirs in their use
9663 of mainstem areas. Juvenile salmon and steelhead may pass through juvenile bypass systems,
9664 spillways, or turbines, or be collected and transported. Adult salmon and steelhead migrating
9665 upstream to their spawning grounds must use fish ladders, also called fishways. Dam
9666 operations may also alter river flows, affect water quality and temperature, create changes in
9667 reservoir elevations, affect the time it takes juvenile salmon to migrate downstream from their
9668 natal streams to the estuary (travel time). Dam operations also affect access to, and the quality
9669 of, critical and essential habitat. Section 3.2, *Hydrology and Hydraulics*, provides a detailed
9670 discussion of CRSO effects on hydrology, and Section 3.4, *Water Quality*, provides a detailed
9671 discussion of CRSO effects on water quality.

9672 The environmental consequences analysis for anadromous fish (Section 3.5.1) is organized by
9673 species rather than by Regions A, B, C, and D in order to facilitate descriptions common to the
9674 species across specific runs throughout the Columbia Basin. The environmental consequences
9675 analysis for resident fish (Section 3.5.2) is organized by region because the effects on those
9676 species are similar in these geographic areas. With regards to potential effects in the Canadian
9677 portions of the Kootenai and Pend Oreille rivers downstream of CRS projects, the effects in this
9678 resource area under the No Action and multi-objective alternatives are expected to be similar
9679 to the effects described on those tributaries in the United States.

9680 In both sections, effects to ESA-listed fish are generally displayed first, followed by unlisted fish.
9681 Changes to physical habitat characteristics important to fish, such as reservoir elevations, river
9682 flows, and water temperatures, are analyzed in detail in other sections (i.e., water quality
9683 [Section 3.4], hydrology and hydraulics [Section 3.2], and river mechanics [Section 3.3]) and
9684 only briefly reiterated in the fish analyses as important drivers of fish effects.

9685 **3.5.3.1 Methodology**

9686 **CONCEPTUAL ECOLOGICAL MODELS**

9687 Conceptual ecological models (CEMs) were developed for key species to document a common
9688 understanding of the relationships between a species' needs and their environment and how
9689 controlling factors such as CRS operations can influence those environmental factors. CEMs
9690 consist of four levels:

- 9691 • The species' life stages to fulfill their life cycle (i.e., eggs, larvae, juveniles, adults).
- 9692 • The critical activities and processes an individual needs in order to successfully complete
9693 that life stage and move on to the next (i.e., habitat needs, food, predation avoidance, and
9694 migration).
- 9695 • The environmental habitat elements that influence those critical activities and processes
9696 (i.e., water temperature, substrate, flows, nutrients, prey, and predators)
- 9697 • Controlling factors that affect those habitat elements that, in turn, affect the critical
9698 activities or processes that species needs to successfully complete its life cycle.

9699 Each of these levels is connected with a series of links (arrows) to demonstrate how controlling
9700 factors, habitat elements, critical activities and process, and life stages are related; how
9701 important that relationship is (magnitude); and how certain the scientific basis of these
9702 relationships is (link understanding). See Appendix E for more details and for CEMs developed.

9703 **WORKSHOPS**

9704 Multiple full day effects analysis workshops were held in Oregon, Washington, and Idaho during
9705 January through June 2019. Participants included fish experts from the three co-lead agencies
9706 as well as from many cooperating agencies. At the workshops, CEMs helped identify key
9707 relationships between the MOs and fish species, and application of those relationships at the
9708 location-specific level were discussed. Data from the water quality, hydrology/hydraulics, and
9709 other sources were then analyzed to produce quantitative or qualitative assessments of effects
9710 under the No Action Alternative and changes under the four MOs. Key relationships and how
9711 they would be affected under each alternative were recorded. This information was then used
9712 to draft the environmental consequences of the MOs. Different tools were used as appropriate
9713 to evaluate different anadromous fish species or resident communities.

9714 **MODELS AND OTHER TOOLS TO ANALYZE EFFECTS TO ANADROMOUS FISH**

9715 Tools available for anadromous salmonids varied by species, ESU, and DPS; the tools are
9716 described in the following sections. Salmon and steelhead ESUs and DPSs that had a basis for
9717 numerical modeling were the upper Columbia River spring Chinook salmon, upper Columbia
9718 River steelhead, Snake River spring Chinook salmon, and Snake River steelhead. Modeled
9719 outputs described below were used to evaluate the effects to these ESUs and DPSs that were
9720 numerically modeled. Other salmon and steelhead that exhibit similar migration characteristics
9721 (such as mid-Columbia and lower Columbia steelhead and salmon, sockeye salmon, and coho
9722 salmon) were evaluated using both qualitative and "surrogate" methodology where the
9723 outputs for a modeled species were used to provide insights to the effects of the other species
9724 (Table 3-60). Where an appropriate model or surrogate was not available, a qualitative
9725 evaluation of hydrology and water quality data was used to evaluate changes to the
9726 environmental factors important to the processes of the life stages, as illustrated by the CEMs.
9727 Species evaluated only qualitatively include fall-run Chinook salmon, Pacific eulachon, green
9728 sturgeon, Pacific lamprey, and American shad.

9729 Fish models were available to predict several juvenile and adult survival metrics for upper
9730 Columbia spring Chinook salmon, upper Columbia steelhead, Snake River spring Chinook
9731 salmon, and Snake River steelhead. Where more than one model was available (i.e., both
9732 COMPASS and CSS), results from both are presented and discussed. Unless otherwise noted,
9733 quantitative results from COMPASS, CSS, and the Life Cycle Model (LCM) are based on a
9734 combination of hatchery and natural origin fish. This applies for both juvenile and adult results.

9735 Anadromous Fish models used in this analysis and the results they produced are discussed
9736 below, and with additional detail in Appendix E. All models described below that will be used
9737 for decision-making will go through the Corps of Engineer's required Independent External
9738 Review Process.

9739 • Comprehensive Passage Model (COMPASS) – The COMPASS model produced juvenile
9740 survival metrics for upper Columbia and Snake River ESUs of spring Chinook salmon and
9741 steelhead. COMPASS estimates passage and survival rates based on relationships that were
9742 developed using a mix of hatchery and wild fish as its data source, therefore results for this
9743 EIS analysis are based on hatchery and wild stocks combined. COMPASS breaks survival into
9744 multiple individual route of passage survivals for each reach (spill, bypass, turbine, and
9745 other configuration routes for each dam).

9746 • National Marine Fisheries Service (NMFS) Life Cycle Model (LCM) – The LCM used COMPASS
9747 inputs to produce estimates of adult return metrics for one population of upper Columbia
9748 spring Chinook salmon (Wenatchee) and for three major population groups of Snake River
9749 spring-run Chinook salmon (South Fork Salmon, East Fork Salmon, and Upper Salmon). The
9750 results were used for comparison purposes to illustrate the response of the upper Columbia
9751 and Snake River spring-run Chinook salmon ESUs, respectively, to each of the MOs. The
9752 NMFS LCM models were developed using a combination of hatchery and wild fish data and
9753 the results presented in this EIS analysis reflect expected responses from the combined
9754 hatchery and wild components of each population/MPG.

9755 Similar to analyses performed during the development of the 2019 NMFS BiOp on
9756 Columbia and Snake River operations, the LCM also used a sensitivity analysis to assess
9757 potential effects of reductions in latent mortality. The purpose was to better understand
9758 to what degree the other latent effects hypotheses could affect the NWFSC life cycle
9759 modeling outputs. The additional four NWFSC scenarios were 10 percent (1.10
9760 multiplier), 25 percent (1.25 multiplier), 50 percent (1.50 multiplier), and 100 percent
9761 (2.0 multiplier) and were applied to the ocean survival of smolts that were estimated to
9762 have migrated in river, i.e. those juveniles not collected and transported at Lower
9763 Granite, Little Goose, or Lower Monumental Dams did not receive the multiplier benefit.
9764 The results of this analysis produced estimates of changes in adult return abundance
9765 should ocean survival improve due to reduced latent mortality

9766 • Comparative Survival Study (CSS) – The CSS cohort modeling considered all fish originating
9767 from the Snake basin and related SARs and in-river metrics. The CSS also used a Grande
9768 Ronde LCM to produce juvenile and adult metrics for the Grande Ronde/Imnaha major

9769 population group of the Snake River spring-run Chinook and steelhead. CSS models treat the
9770 entire CRS as an aggregate of two routes of passage (number of powerhouses passed vs
9771 spilled on average). CSS models make statistical estimations of the effect of the freshwater
9772 CRS on latent ocean mortality. Results were used for comparison of the Snake River spring-
9773 run Chinook and steelhead ESUs to the MOs. The CSS models were developed using a
9774 combination of hatchery and wild fish data and the results presented in this EIS analysis
9775 reflect expected responses from the combined hatchery and wild components of each
9776 population/MPG. The CSS group also produced results that were based on wild fish only at
9777 the request of the co-lead agencies. Those results were considered but did not show
9778 fundamental differences from the combined hatchery/wild estimates. Because the CSS wild
9779 only estimates still do not reflect what survival would be for wild fish in the absence of
9780 hatchery fish, and in an effort to maintain as much consistency with the data used in the
9781 LCMs, the wild only data was not reported in this chapter but it is included as a memo in
9782 Appendix E.

9783 ***Indicators and Primary Metrics***

9784 Specific juvenile- and adult-modeled metrics

9785 The following measurements are included in ESU/DPS-specific sections for upper Columbia
9786 River spring Chinook salmon, upper Columbia River steelhead, Snake River spring Chinook
9787 salmon, and Snake River steelhead, where applicable:

- 9788 • Average juvenile survival.
- 9789 • Average juvenile travel times.
- 9790 • Proportion of juveniles originating upstream of Lower Granite Dam that are destined for
9791 transport.
- 9792 • Average number of powerhouse passage events³ for a juvenile fish passing from Lower
9793 Granite or Rock Island Dam (as applicable) to Bonneville Dam. Transported fish or fish that
9794 do not survive to Bonneville would only experience a portion of the average powerhouse
9795 passage value listed for each ESU/DPS.
- 9796 • Smolt to adult return rates (SARs) are expressed as a percentage of smolts migrating
9797 downstream from one specific point and returning to a specific point as an adult.
- 9798 • Estimates of adult abundance for the populations modeled. It is important to note that
9799 adult abundance models are available only for a portion of the populations, and abundance
9800 should be used as an index to compare MOs rather than actual predicted abundances.
- 9801 • All fish model metrics are presented in the primary results tables as a mean without
9802 estimates of either natural variance, or standard error representing sources of model

³ The COMPASS and CSS cohort models use differing assumptions regarding structures that are surface and powerhouse passage routes. COMPASS characterizes turbine and bypass routes as powerhouse passage routes in calculations for powerhouse passage events, while CSS adds ice and trash sluiceways to the list of routes that are powerhouse passage routes.

9803 uncertainty. The 80-year water record used as input for the models represents the long-
9804 term variance in seasonal flow, temperature and other environmental variables. In the
9805 appendix, 95 percent confidence intervals and standard deviation are presented for the in-
9806 river juvenile survival metric, and 50 percent and 95 percent quantiles are presented for
9807 adult abundance for the NWFSC life cycle model.

9808 **COMPARISON OF COMPASS AND CSS MODELS**

9809 COMPASS and CSS are models used to evaluate the effects of the Columbia River System. They
9810 can be viewed as best available model systems developed over two decades through
9811 collaborations of universities, state and federal agencies, and stakeholders. The models both
9812 describe fish survival and migration through the system and ocean but use different processes
9813 and selections of data. COMPASS links independently calibrated system (COMPASS 2008) and
9814 ocean survival models (Scheuerell et al. 2009) and in the future other factors (personal
9815 communication, Widner and Falkner). CSS describes the entire life cycle calibrated in a single
9816 integrated statistical process (McCann et al. 2017).

9817 The models predict different outcomes for potential system actions, such as increased spill and
9818 dam removal. COMPASS predicts small increases in returns while CSS predicts increasing spill to
9819 125 percent TDG would roughly double the adult salmon returns. These divergent predictions
9820 are striking because both models fit smolt system passage and adult return data from the late
9821 1990s to the present reasonably well. Thus, it is difficult to evaluate the models based on their
9822 fits to data alone. While the models apply different assumptions and predict survival with
9823 different environmental variables on different temporal scales, the divergent predictions are
9824 the result of only a few critical assumptions. The paragraphs below highlight the assumptions,
9825 identify the critical ones, and illustrate how they along with critical data shape the different
9826 predictions.

9827 • **System survival:** The models calibrated system survival using different data. COMPASS used
9828 hydroacoustic, PIT, radio and acoustic tagged juveniles after 1990 to calibrate daily reservoir
9829 and dam survivals. The covariates explaining the survival included daily river flow,
9830 temperature, and route-specific passage through the dams. CSS used “freeze-brand”
9831 marking method prior to 1990 and PIT tag data thereafter. In addition, the CSS calibration
9832 used SAR data collected by various methods from the 1960s. The number of powerhouses
9833 (PH) that juveniles passed through and the water travel time (WTT) explained the biweekly
9834 and seasonal survival. System survivals to Bonneville Dam were similar in the two models.
9835 Thus, the differences in assumptions and data do not explain the differences in the effect of
9836 system operations on adult returns.

9837 • **Ocean survival:** The differences in how the models link system experience to ocean
9838 mortality is the critical factor in explaining effects of system operations on adult returns. In
9839 the COMPASS model, the day of year that juvenile fish arrive at Bonneville Dam and the
9840 daily river temperature residual both affect ocean survival (Scheuerell et al. 2009). In
9841 general, later arriving fish experience lower ocean survival. In turn, ocean arrival date
9842 depends on the date fish enter the system, river flow, and passage delay at dams. Higher

9843 flows and spill reduce WTT and delay at dams, which together promote earlier ocean arrival
9844 and higher ocean survival. Importantly, the survival-arrival date relationship is only weakly
9845 linked to spill or PH passage. In contrast, CSS links PH passage to ocean survival such that
9846 the construction of dams through the 1970s resulted in greater PH passage with successive
9847 decreases in freshwater and ocean survival. Likewise, bypassing the PH and instead passing
9848 via spillways or surface passage routes increases ocean survival. Both models include
9849 environmental variables; COMPASS includes the residual of the daily river temperature and
9850 CSS includes an index of the ocean temperature anomaly, the Pacific Decadal Oscillation
9851 (PDO), plus an index of coastal upwelling.

9852 • **Independent Scientific Review:** Both COMPASS and CSS have been through multiple rounds
9853 and various forms of scientific peer review. The COMPASS model was published in a peer-
9854 reviewed scientific journal when it was released in 2008 (Zabel et al. 2008). Similarly, as
9855 noted above, many of the underlying drivers to the results from the CSS model(s) are based
9856 on mechanisms that were published in peer reviewed journal submissions (e.g., Haeseker et
9857 al. 2012).

9858 In addition to these reviews, the NW Power and Conservation Council's Independent
9859 Scientific Advisory Board (ISAB) has reviewed both models over the course of their
9860 development. The ISAB reviewed the initial stages of development for the COMPASS
9861 model when it was first released in 2007 (ISAB 2007-1 and ISAB 2008-3) for use during
9862 NMFS's preparation of the 2008 Biological Opinion. The ISAB has also review each CSS
9863 annual review report since the CSS 10-year retrospective analysis was released in 2007
9864 (ISAB/ISRP 2007-6). The ISAB has provided both technical comments and guidance for
9865 the direction of future research areas.

9866 As noted above, highly divergent predictions of smolt to adult return rates between the
9867 CSS and COMPASS models are driven by differing approaches to latent mortality
9868 employed by the two models. These different approaches have been one of the primary
9869 focuses of ISAB reviews.

9870 The ISAB reviews have evolved over the past decade but still have not settled on a
9871 preferred approach to attribute the cause or magnitude of the effect of latent mortality.
9872 Guidance from the ISAB has evolved from a 2007 recommendation to stop attempting
9873 to measure absolute latent mortality (ISAB 2007-1). In 2012, ISAB recommended a
9874 continuation of research efforts to assess the potential causal mechanisms of observed
9875 latent effects associated with bypass systems (ISAB 2012-1) to determine if fish were
9876 being damaged by the bypass systems or if smaller weaker fish were being passed at
9877 higher rates through the bypass systems.

9878 In 2017 (ISAB 2017-1), as part of its review of NMFS's life cycle modeling efforts that
9879 were being developed for use in the upcoming 2019 Biological Opinion, the ISAB again
9880 reviewed components of both the COMPASS and the CSS models. The large differences
9881 in predicted smolt-to-adult returns between the two modeling approaches elicited
9882 support from the ISAB to continue research and other analytical efforts to resolve

9883 remaining questions of whether increased spill levels could increase the SARs of
9884 salmonids that migrate through the CRS. In a response to that review, two separate spill
9885 test proposals were developed by the CSS and by NMFS (ISAB 2018-2). That review was
9886 at least a partial genesis for several of the multiple objective alternatives in this EIS
9887 analysis (i.e. block spill test in MO1 and spill to the 125 percent TDG cap in MO4).

9888 Both groups continue to develop their models to address the ISAB's ongoing questions
9889 surrounding the magnitude and the causal mechanisms associated with latent mortality
9890 through the hydrosystem. The CSS continues to analyze and report each year on
9891 patterns in overall SARs. NMFS has recently focused on the ISAB's questions on the
9892 condition of fish using the powerhouse (more specifically the bypass systems). Their
9893 most recent publication (Faulkner et al. 2019) demonstrated size selective tendencies at
9894 many of the bypass systems in the CRS which would potentially reduce the benefit of
9895 increased spillway passage shown by the CSS model. Faulkner's efforts are consistent
9896 with McMichael et al. (2010) analyzed the passage of yearling Chinook with JSATs
9897 acoustic transmitters at multiple CRS dams, and found that on average, smaller fish used
9898 the bypass routes. The CSS has also investigated this issue and found that the location
9899 where fish were collected and tagged for study is also an important component. This
9900 could be one potential reason for the discrepancies between the model outputs. As the
9901 ISAB noted in their 2017 review of the CSS (ISAB 2017-2) (closely linked to the life cycle
9902 model review [2017-1] noted above), "Modeling flow, spill, and dam breach scenarios is
9903 very useful for policy makers. Consequently, it is important that all assumptions be
9904 clearly stated and that the results are robust to these assumptions. The same scenarios
9905 should be run through both models and discrepancies resolved."

9906 • **Summary:** The COMPASS and CSS model systems both predict the effects of hydrosystem
9907 smolt passage on adult returns of salmon. The models express the freshwater and ocean
9908 mortalities using different variables and equations linking the variables to survival and adult
9909 returns. Both models fit the available SAR reasonably well but predict very different
9910 responses of SAR to spill. The COMPASS model attributes most of the recent variations in
9911 runs to ocean conditions and predicts small effects with changes in spill. The CSS model
9912 attributes approximately two-thirds of the 50-year decline in salmon runs to powerhouse
9913 passage and predicts significant run recovery by increasing spill. The essential differences in
9914 the models involves how they express the effect of freshwater passage experience on ocean
9915 mortality.

9916 • **University of Washington TDG model-** This model, which is separate and distinct from
9917 either the COMPASS or CSS juvenile survival models, estimated juvenile survival by reach
9918 based on reach average exposure to TDG, average juvenile fish migration depth, and
9919 exposure timing. Water that passes through the spillway at mainstem dams can cause
9920 downstream waters to become supersaturated with dissolved atmospheric gasses.
9921 Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in
9922 injury and death (Weitkamp and Katz 1980). Because this model has not been evaluated
9923 thoroughly the survival metrics predicted by this model are reported in the appendices but
9924 are not discussed in the body of this analysis and are not expected to be used as a basis for

9925 decision-making. TDG exposure predictions are used to show relative changes in TDG
9926 amongst the alternatives.

9927 As noted above, the similarities and differences in the two CSS models as well as
9928 COMPASS will be the subject of IEPR, the results of which will inform the final version of
9929 this EIS. The UW TDG model will also be analyzed in the IEPR process. These models are
9930 all discussed in additional detail in Appendix E.

9931 **SURROGATES/QUALITATIVE ANALYSIS**

9932 For some fish species, there is limited or no information on species-specific relationships for
9933 CRS dam and reservoir passage.

9934 Consequently, how these species may respond to system changes is qualitatively assessed using
9935 modeling results from a similar species (surrogate) where similarities have been established
9936 between the species in order to assume similar impacts. Surrogate species were selected based
9937 on outmigration characteristics, life history, and timing similarities. Species with surrogates for
9938 passage effects analysis are shown in Table 3-60. The results of both COMPASS and CSS passage
9939 modeling were considered for the designated surrogate species, if available, and any key
9940 differences in passage between non-modeled and surrogate modeled species are noted. Use of
9941 species surrogates is consistent with Recovery Plans and previous ESA consultations. A more
9942 detailed description of the evaluation of surrogate data is presented in Appendix E.

9943 **Table 3-60. Fish Species for Which Surrogates Were Used for Effects Analysis**

Species Evaluated	Surrogate Used for Analysis
Lower Columbia River Chinook	Snake River spring/summer-run Chinook
Middle Columbia Spring Chinook	Upper Columbia River spring-run Chinook
Lower Columbia River steelhead	Snake River steelhead
Middle Columbia River steelhead	Upper Columbia River steelhead
Upper Columbia sockeye	Upper Columbia River spring-run Chinook
Snake River sockeye	Snake River spring/summer-run Chinook
Lower Columbia River coho	<i>Juveniles</i> - Snake River spring/summer-run Chinook <i>Adults</i> - Snake River fall Chinook (qualitative)
Upper Columbia River coho	<i>Juveniles</i> - Upper Columbia River spring-run Chinook <i>Adults</i> - Columbia River fall Chinook (qualitative)
Snake River coho	<i>Juveniles</i> - Snake River spring/summer-run Chinook <i>Adults</i> - Snake River fall Chinook (qualitative)
Columbia River chum	Snake River spring/summer-run Chinook

9944 **Resident Fish**

9945 All resident fish were evaluated during the workshops to qualitatively assess changes to the
9946 important relationships described by the CEMs and considered local knowledge of how fish
9947 species interact with their environment and one another at the fish community level. See
9948 Appendix E for the suite of CEMs developed for this EIS. Resident fish in the basin have far less
9949 quantitative information that anadromous species; no numerical predictive models were used.

9950 Effects to resident fish were analyzed by eight subbasin teams using predicted metrics, such as
 9951 water flow, elevation, temperature, and DO. Relationships between these metrics and
 9952 biological metrics, as informed by the CEMs, were used to describe expected changes to habitat
 9953 elements, such as productivity, the number of resident fish that are swept downstream past the
 9954 dams due to flows (i.e., entrainment), and habitat losses based upon existing literature or local
 9955 information. Where possible, quantitative data such as the volume of productive reservoir,
 9956 percent changes in outflows, retention time, feet change in elevations, etc. were used to
 9957 describe habitat effects, otherwise qualitative analyses were completed using existing literature
 9958 and expert knowledge from local managers. The teams used this information to qualitatively
 9959 analyze effects to fish resources. See Appendix E, Qualitative Analyses, for a more detailed
 9960 description of the effects analysis and documentation methodology.

9961 **Macroinvertebrates**

9962 Consistent data regarding macroinvertebrate habitats and populations in the Columbia River
 9963 Basin are lacking. To analyze the effects of MOs to these resources, the teams used existing
 9964 literature to compare expected outcomes from the MOs using the hydrology and water quality
 9965 outputs, similar to resident fish analyses.

9966 **3.5.3.2 Summary of Findings from Primary Analyses of Alternatives**

9967 Table 3-61 and Table 3-62 below provide a very high-level overview of the detailed analysis of
 9968 each alternative that follows in this chapter. Quantitative estimates presented in the tables
 9969 below generally represent the average result from model runs that incorporated 80 different
 9970 annual river flow scenarios, each with a different volume and run-off timing component.
 9971 Because the quantitative results below are not presented with any estimates of uncertainty or
 9972 statistical precision (e.g. standard error, or confidence bounds) these estimates are best suited
 9973 for relative comparisons of the differences between alternatives, rather than comparisons
 9974 between models. It is also important to note that for any given measurement type, the CSS, and
 9975 LCM models may produce results for differing river reaches.

9976 **Table 3-61. Overview of Alternative Analysis**

Species	NAA	MO1	MO2	MO3	MO4
Upper Columbia Spring Chinook					
Survival (%) - <i>McNary to Bonneville</i>	69.5	70.0	68.7	70.6	71.0
LCM Powerhouse Passage <i>Rock Island to Bonneville</i>	3.29	3.08	3.66	2.89	2.53
LCM Smolt to Adult Return Rate (%) <i>Rock Island to Bonneville</i>	0.94	0.95	0.93	0.95	0.96
Upper Columbia Steelhead					
Survival (%) <i>McNary to Bonneville</i>	65.8	65.6	64.0	66.2	66.1
LCM Powerhouse Passage <i>Rock Island to Bonneville</i>	2.72	2.59	2.89	2.52	2.31
LCM Smolt to Adult Return Rate (%)	NA	NA	NA	NA	NA

Species	NAA	MO1	MO2	MO3	MO4
Snake River Spring Summer Chinook					
CSS Survival (%) – <i>Lower Granite to Bonneville</i>	57.6	58.3	53.7	68.2	63.5
LCM Survival (%) – <i>Lower Granite to Bonneville</i>	50.4	51.0	50.1	60.0	50.7
CSS Powerhouse Passage (PITPH)	2.15	1.74	3.48	0.56	0.34
LCM Powerhouse Passage	2.25	1.88	3.02	0.66	0.49
CSS Smolt to Adult Return Rate (%)	2.0	2.2	1.4	4.3	3.5
LCM Smolt to Adult Return Rate (%)	0.88	0.88	0.90	1.0	0.77
Snake River Steelhead					
CSS Survival (%) – <i>Lower Granite to Bonneville</i>	57.1	58.8	44.4	83.1	73.7
LCM Survival (%) – <i>Lower Granite to Bonneville</i>	42.7	42.2	40.2	52.7	43.1
CSS Powerhouse Passage (PITPH)	1.96	1.64	3.26	0.46	0.28
LCM Powerhouse Passage	1.73	1.47	2.26	0.42	0.35
CSS Smolt to Adult Return Rate (%)	1.8	1.9	1.3	5.0	3.1
LCM Smolt to Adult Return Rate (%)	NA	NA	NA	NA	NA

9977 **Table 3-62. Overview of Alternative Analysis (MO1 – MO4)**

Species	MO1	MO2	MO3	MO4
Other Anadromous Stocks				
Chum	2% Decrease in meeting Chum Flows - Minor Adverse	3% Decrease in meeting Chum Flows - Minor Adverse	1% Increase in meeting Chum Flows - Minor Beneficial	12% Decrease in meeting Chum flows - Moderate Adverse
Fall Chinook	UC: Similar to NAA. SR: Warmer Water leads to minor increases in Straying and fallback	UC: Similar to NAA. SR: Increased transport leads to minor increases in straying and fallback	UC: Similar to NAA. SR: Short term major adverse (large mortality event during breaching) and long-term Major Beneficial (large increase in habitat)	UC: increased TDG and more days with higher water temperature in late summer leads to minor adverse. SR: Similar to NAA - with minor adverse effects from TDG
Sockeye	UC: Similar to NAA. SR: Warmer water leads to minor increases in Straying and fallback	UC: Slightly lower Survival expected - Minor effect. SR: Increased transport leads to minor increases in straying and fallback	UC: Similar to NAA SR: Short term major adverse (large mortality event during breaching) and long-term Moderate Beneficial (increased survival)	UC: increased TDG and more days with higher water temperature in late summer leads to minor adverse. SR: ~NAA - with minor adverse effects from TDG

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Species	MO1	MO2	MO3	MO4
Resident Fish				
Region A	Kootenai: Mixed beneficial and adverse effects due to food availability. Minor adverse effects to burbot and sturgeon Hungry Horse: Minor to moderate adverse effects due to food availability, entrainment, varial zone, and river habitat. Pend Oreille similar to NAA.	Kootenai: Minor adverse effects to riparian and sturgeon, minor beneficial effects to river habitat. Hungry Horse: Moderate to major adverse effects due to food availability, varial zone, entrainment, and river habitat. Pend Oreille similar to NAA.	Kootenai: Minor to moderate adverse effects due to food availability, riparian, and to sturgeon; minor beneficial effect due to river habitat suitability. Hungry Horse: Minor to moderate adverse effects due to food availability, entrainment, varial zone effects, and river habitats. Pend Oreille similar to NAA.	Kootenai: Minor beneficial effects to riparian; minor to moderate adverse effects due to reservoir habitat and tributary access. Hungry Horse: Moderate to major adverse effects due to food availability, varial zone, entrainment, and river habitat, especially in dry years. Pend Oreille: Minor to moderate adverse effects due to riparian habitat and tributary access.
Region B	Minor to moderate adverse effects to productivity, entrainment, egg stranding, tributary access, and varial zone effects. Minor adverse effect to sturgeon.	Moderate and localized major adverse effects to productivity, entrainment, egg stranding, tributary access, and varial zone effects. Sturgeon similar to NAA.	Minor adverse effects to entrainment and productivity; most metrics similar to No Action Alternative, negligible, or minor. In McNary reservoir, major beneficial effect to sturgeon recruitment and connectivity, but short-term minor adverse effects from breaching effects.	Moderate to major adverse effects to productivity, entrainment, stranding of eggs, and varial zone effects, especially in dry years. Sturgeon similar to No Action Alternative.
Region C	Minor adverse effects to native fish due to temperatures in lower Snake River.	Minor to moderate to adverse effects to kokanee and bull trout entrainment in winter from Dworshak; lower Snake River increased turbine route passage but lower TDG.	Short term: moderate to major adverse construction effects. Long-term: Major beneficial effects due to reconnection of fragmented populations and increased sturgeon spawning habitat.	Minor to moderate adverse effects due to increased TDG.

Species	MO1	MO2	MO3	MO4
Region D	Negligible effects to flows and water temperature; minor adverse potential sturgeon effects.	Negligible effects to flow and water temperature.	Negligible effects to flow and water temperature.	Negligible effects to flow and water temperature; minor adverse effects due to increased TDG.

9978 **3.5.3.3 No Action Alternative**

9979 **ANADROMOUS FISH**

9980 **Salmon and Steelhead**

9981 Several different ESUs and DPSs of salmon and steelhead share a similar life cycle and would
 9982 experience similar effects under the No Action Alternative but also have specific traits that
 9983 affect the units differently from one another. Common effects analyses across all salmon and
 9984 steelhead are discussed first, followed by analysis of effects specific to each ESU/DPS. Note the
 9985 common effects described in this section are not repeated in the species-specific sections but
 9986 assumed to apply unless stated otherwise. Also, unless otherwise noted, quantitative results
 9987 from COMPASS, CSS, and the Life Cycle Model (LCM) are based on a combination of hatchery
 9988 and natural origin fish. This applies for both juvenile and adult results.

9989 ***Ongoing Existing Mitigation Programs***

9990 There are numerous actions to benefit salmon and steelhead in the Columbia River Basin.
 9991 Below Chief Joseph Dam, ongoing activities for anadromous fish would continue, including
 9992 tributary habitat improvement actions for ESA-listed anadromous stocks, estuary habitat
 9993 improvement actions for juvenile salmonids and steelhead species, and fish hatchery programs
 9994 as discussed in a few examples below.

9995 **Habitat**

9996 Throughout Regions C and D, the Bonneville F&W Program annually funds tributary habitat
 9997 improvement actions for ESA-listed anadromous stocks, such as Snake River steelhead distinct
 9998 population segment, Snake River spring/summer Chinook salmon evolutionary significant unit,
 9999 and the Middle Columbia steelhead distinct population segment. Examples of these habitat
 10000 improvement actions include the following: fish passage and barrier removal; fish screening;
 10001 instream flow acquisition; habitat protection through acquisition; river, floodplain and wetland
 10002 habitat improvements; and riparian planting and fencing. For example, the Shoshone-Bannock
 10003 Tribes of the Fort Hall Reservation have enhanced over five miles of the Yankee Fork Salmon
 10004 River to promote anadromous and resident fish habitat.

10005 Further, in Region D, co-lead agencies would continue to implement habitat restoration actions
 10006 in the Columbia River Estuary. These actions primarily focus on the restoration of disconnected
 10007 tidally influenced floodplain ecosystems for all juvenile salmonids and steelhead species in

10008 order to provide greater opportunity, access, and capacity for juvenile salmonid and steelhead
10009 rearing conditions.

10010 Hatcheries

10011 In Region B, the Confederated Tribes of the Colville Reservation operate the Chief Joseph
10012 Hatchery on the Colville Reservation below Chief Joseph Dam, releasing smolts to increase the
10013 abundance of adult summer/fall and spring Chinook to the Okanogan River and Columbia River
10014 mainstem above the Okanogan River confluence for conservation and harvest purposes, and
10015 assist in re-establishing a fourth population of upper Columbia River spring Chinook in the
10016 Okanogan River Basin through reintroduction of an experimental population under the ESA.

10017 In Region C, Bonneville F&W Program-funded hatchery programs include the captive
10018 propagation for critically endangered Snake River sockeye, Snake River spring/summer Chinook
10019 supplementation, Snake River fall Chinook supplementation and the reconditioning of Snake
10020 River steelhead kelts. For example, the Nez Perce Tribal Hatchery produces Snake River
10021 spring/summer Chinook and Snake River fall Chinook. Further, the Springfield Hatchery, located
10022 near American Falls, Idaho, was constructed to address recovery objectives for ESA-endangered
10023 Snake River Sockeye Salmon. Dworshak National Fish Hatchery produces juvenile steelhead to
10024 mitigate for the construction of Dworshak Dam.

10025 In Region D, Bonneville F&W Program-funded hatchery programs include coho reintroduction
10026 and supplementation in the Mid-Columbia, through hatcheries like the newly constructed
10027 Melvin R. Sampson Hatchery operated by the Yakama Nation, and reconditioning of Mid-
10028 Columbia steelhead kelts. Bonneville also funds WDFW to produce chum salmon fry in the
10029 Columbia River estuary. The Dalles and John Day Dams Mitigation Program produces fall
10030 Chinook to mitigate for the construction of the dams.

10031 ***Effects Common Across Salmon and Steelhead***

10032 Summary of Key Effects

10033 A variety of factors, including project structures, surface passage modifications, natural
10034 mortality, and predation affect juvenile migration and survival at the lower Columbia River and
10035 lower Snake River projects. Adult migration is affected by dam passage, predation, and
10036 temperature and flow conditions. The measures in the No Action Alternative are not expected
10037 to change these factors, although temperature and flow conditions may be impacted by climate
10038 change. Unless otherwise noted, quantitative results from COMPASS and the Life Cycle Model
10039 (LCM) are based on a combination of hatchery and natural origin fish. This applies for both
10040 juvenile and adult results.

10041 Juvenile Migration/Survival

10042 Juvenile salmon and steelhead can pass dam structures on the Columbia River by spillways,
10043 turbines or bypass structures. For each species of salmon, each route has an associated

10044 frequency and median survival rate. In general, bypass and spillway routes are associated with
10045 relatively higher juvenile salmon survival than turbines routes. Spill levels, spill patterns, and
10046 turbine priorities also have significant effects on the survival rates of migrating juveniles via
10047 their influence on tailrace hydraulics and the formation of eddies. As a result, alternatives that
10048 route more fish through turbines would be associated with lower juvenile survival. Currently,
10049 the majority of all juveniles pass the federal dams via spillway routes. Estimates from studies to
10050 evaluate route specific survival show that between 70 and 97 percent of all juvenile salmon
10051 pass via spillway routes. Currently, survival rates from these routes range from 97 to 99 percent
10052 (Ploskey et al. 2012). Under the No Action Alternative, these survival rates would continue.

10053 Spill affects juvenile migration routes through the projects. Increased spill generally reduces
10054 travel time as fish find spill routes more readily than turbine routes. The forebays of dams
10055 provide habitat for reservoir predators, and the likelihood of encountering predators is
10056 increased as juvenile salmon spend more time searching for a passage entrance. Additionally,
10057 more spill generally means fewer powerhouse encounters, which would increase survival
10058 because turbines are generally associated with lower juvenile survival. Spill is not expected to
10059 change under the No Action Alternative. However, under this alternative, the co-lead agencies
10060 have incorporated expected improvements from new turbines designed for improved fish
10061 passage (IFP). Three new IFP turbines are currently being installed at Ice Harbor dam, and all
10062 turbines at McNary Dam are expected to be replaced between 2022 and 2032.

10063 All four lower Columbia River and four lower Snake River CRS projects have available surface
10064 passage routes and/or structures in addition to 24-hour spring and summer spill programs to
10065 facilitate faster juvenile passage and higher survival. The surface passage modifications
10066 operated at the dams are generally among the highest survival routes available for juvenile
10067 salmonids, and their influence on improving spill passage efficiency and reducing forebay delay
10068 has been tested and monitored over time to meet performance criteria. Dam tailraces can
10069 increase predation risk when juvenile fish are pulled in eddies or countercurrents, and
10070 entrainment into spillway stilling basins increases the risk of injuries. Optimum tailrace
10071 hydraulics are achieved when flows are balanced among all spillway and turbine routes to
10072 achieve uniform downstream flow, which is influenced by overall discharge and spill levels.
10073 Most bypass outfalls at CRS dams have been relocated to ensure that smolts are not released
10074 into areas prone to eddies or slow velocities. Most Snake River fish pass the four lower Snake
10075 and four lower Columbia CRS projects, while the upper Columbia River fish pass up to five non-
10076 Federal middle Columbia River dams and four lower Columbia River CRS projects. Depending on
10077 model output and data availability, effects were generally evaluated for federally owned and
10078 operated projects but in some cases included passage effects associated with passage at the
10079 middle Columbia PUD projects. A variety of factors other than project structures, such as river
10080 flows, can affect the rate of downstream migration of juveniles and may affect juvenile
10081 migration and survival.

10082 Several measures in the No Action Alternative can affect juvenile fish transportation rates,
10083 including *Storage Project Operations*, *Lower Columbia and Snake River Operations*, *Spill*
10084 *Operations to Improve Juvenile Passage*, and *Fish Passage Plan*, and the extent of these effects

10085 differ by fish population. The greatest effects to transport result from impacts from flows and
10086 the proportion of flow spilled. The greater the proportion of the flow that is spilled, the fewer
10087 fish available for transport. Under the No Action Alternative, approximately 39 percent of all
10088 Snake River Chinook and 40 percent of all Snake River steelhead would be destined for
10089 transport. Only Snake River species are transported.

10090 Biological monitoring shows that the incidence of GBT in migrating smolts remains between 1
10091 and 2 percent when TDG concentrations in the upper water column remain below 120 percent
10092 of saturation in CRS project tailraces (NMFS 2019). TDG modeling predicted that the average
10093 exposure to juveniles on their migration route for all species would be about 115 percent for
10094 the No Action Alternative. This value is relatively high, but current observations of similar values
10095 have not revealed high levels of injury or mortality for yearling Chinook salmon.

10096 Colonial waterbirds that eat fish (i.e. piscivorous birds)—especially terns, cormorants, and
10097 gulls—are having a measurable impact on juvenile salmonid survival in the Columbia River
10098 (NMFS 2019), both as proximate and direct sources. Management efforts are ongoing to
10099 reduce salmonid consumption by terns in the lower Columbia River, and similar efforts are in
10100 progress to reduce the nesting population of double-crested cormorants in the estuary. The
10101 Corps has been implementing the Caspian Tern and Double-crested Cormorant Management
10102 Plans. Predation rates have been reduced at the managed locations in the estuary and inland
10103 nesting sites, but due to the reduction in habitat and hazing actions, terns and cormorants have
10104 dispersed to other locations within the basin that are outside of the authority of the co-lead
10105 agencies. Moderate reductions in predation by colonial waterbirds in the Columbia River
10106 System and estuary resulting from the avian management plans are expected to continue under
10107 the No Action Alternative through the measures of *Reduce Caspian Terns on East Sand Island in*
10108 *the Columbia River Estuary and Double-crested Cormorant Management*.

10109 Native northern pikeminnow, and non-native walleye, smallmouth bass, and channel catfish are
10110 major predators of juvenile salmonids in the Columbia River (reviewed in ISAB 2015). The
10111 Northern Pikeminnow Management Plan was initiated in 1990 to reduce predation of juvenile
10112 salmon and steelhead. Before the start of the Northern Pikeminnow Management Plan in 1990,
10113 northern pikeminnow were estimated to eat about 8 percent of the 200 million juvenile
10114 salmonids that migrated downstream in the Columbia River each year. Williams et al. (2017)
10115 compared current estimates of northern pikeminnow predation rates on juvenile salmonids to
10116 before the start of the program and estimated a median reduction of 40 percent. Under the No
10117 Action Alternative, these rates are expected to continue. Additionally, non-native northern pike
10118 are present in Lake Roosevelt and, despite current suppression efforts, are likely to invade
10119 further downstream, adding another piscivorous (i.e., fish eating) predator to salmon and
10120 steelhead migration routes. Non-native walleye, smallmouth bass, channel catfish, and
10121 northern pike would continue to consume an additional unknown number of juvenile salmon
10122 and steelhead under the No Action Alternative.

10123 Adult Migration/Survival

10124 CRS factors that affect the survival rates of migrating adults include dam passage, where adults
10125 must find and ascend ladders and re-ascend the ladders if they fall back through spillways or
10126 other routes. Another factor is straying to non-natal tributaries either naturally or as a result of
10127 impaired homing stemming from transport, hatchery rearing (Westley et al. 2013), or other
10128 factors, such as temperature and flow conditions that can increase energetic demands of
10129 migrating fish and predation (Keefer et al. 2004; NMFS 2008a). In general, higher flows and
10130 higher spill levels lead to longer migration timing and can contribute to site specific delays for
10131 adult salmonids through the CRS projects. High water temperatures can cause migrating adult
10132 salmon to stop or delay their migration or can increase fallback after ascending fish ladders.
10133 During upstream migration, a temperature difference of more than 2°C in the fish ladders
10134 compared to river water can also delay adult migration. Under typical conditions, after
10135 accounting for harvest, adult salmonids typically have relatively high migration success through
10136 lower Columbia River and lower Snake River dams and reservoirs within the CRS (Keefer et al.
10137 2016).

10138 Adult migration success is not expected to change over time due to these factors under the No
10139 Action Alternative, but water temperature and flow changes expected from climate change,
10140 and their potential effects on fish species, are discussed in Chapter 4, Climate Change.

10141 Seals and sea lions (pinnipeds) eat returning adult salmon and steelhead in the estuary and
10142 upstream to Bonneville Dam (Brown et al. 2017; Chasco et al. 2017; NMFS 2019), though
10143 occasionally some pinnipeds move up into the Bonneville pool as well. Similar to many natural
10144 fish passage impediments (e.g., waterfalls, cascades), dams or dam operations can also delay or
10145 create concentrations of adult fish searching for ladder entrances (Quinones et al. 2015), which
10146 can in turn make adult salmon and steelhead in those locations more vulnerable to predation
10147 by pinnipeds (Stansell 2004; Naughton et al. 2011). Given that the populations of Steller's and
10148 California sea lions have experienced average annual increases of 4.888 percent and 6.2
10149 percent, respectively since the 1980s, pinniped predation rates are expected to continue
10150 increasing under the No Action Alternative. However, the predation rates at Bonneville Dam
10151 can be affected through pinniped hazing and removal. Spill operations under the No Action
10152 Alternative do not appear to affect sea lion predation downstream of Bonneville Dam.

10153 Biological monitoring shows that the current incidence of GBT in migrating adults remains
10154 between 1 to 2 percent when TDG concentrations in the upper water column remain below 120
10155 percent TDG saturation in CRS project tailraces (NMFS 2019). GBT can reduce adult salmon and
10156 steelhead fitness and the number of fish returning to spawn. Operations under the No Action
10157 Alternative target spill levels less than 120 percent TDG through the *Spill Operations and Water*
10158 *Quality Plan for TDG and Water Temperature* measures; however, high river discharges can
10159 occasionally result in TDG levels above 120 percent.

10160 ***Upper Columbia River Salmon and Steelhead***

10161 Upper Columbia River salmon and steelhead migrate past up to five non-Federal dams and
10162 reservoirs that also impact the survival and passage of these species. The co-lead agencies do

10163 not dictate generation or spill levels at these projects operated by the Public Utility Districts of
10164 Douglas, Chelan, and Grant counties; therefore, adult and juvenile metrics, such as powerhouse
10165 encounter rate, are not directly affected but are influenced by river flow levels coming through
10166 the upper Basin. The timing and volume of flow levels affected by CRS operational decisions are
10167 reflected in model analysis from McNary Dam to Bonneville Dam or from Rock Island Dam to
10168 Bonneville depending on model output. CSS model results are not available for upper Columbia
10169 stocks. Additional model output is presented in Appendix E.

10170 Upper Columbia River Spring-Run Chinook Salmon

10171 *Summary of Key Effects*

10172 COMPASS estimates juvenile survival of upper Columbia River spring-run Chinook salmon from
10173 McNary Dam to Bonneville Dam would be 69.5 percent under the No Action Alternative. While
10174 no estimates of adult survival were generated as part of the CRSO EIS, the 10-year average
10175 survival for adult upper Columbia River spring-run Chinook salmon from Bonneville to McNary
10176 Dam is 91.5 percent. The CSS did not analyze effects of any alternative on Upper Columbia
10177 Chinook salmon so there are no results presented in this section. For context, CSS estimates of
10178 smolt-to-adult returns based on run reconstruction are provided but these estimates do not
10179 necessarily entirely reflect the No Action Alternative.

10180 *Juvenile Migration/Survival*

10181 The COMPASS model was used to estimate juvenile survival, travel time, for upper Columbia
10182 River spring-run Chinook salmon from McNary Dam to Bonneville Dam, and powerhouse
10183 encounters from Rock Island to Bonneville under the No Action Alternative. TDG average
10184 exposure was calculated as the level of TDG that a specific group of fish would experience as they
10185 migrate, at depth, through the system.

10186 Under the No Action Alternative, J upper Columbia spring-run Chinook salmon survival rates from
10187 McNary Dam to Bonneville Dam under the No Action Alternative would be approximately 70
10188 percent. By comparison, Widener et al. (2018) reported that hatchery-origin juvenile upper
10189 Columbia River spring-run Chinook salmon survival rates for this same reach of river averaged 84
10190 percent from 2008 to 2017. TDG average exposure was calculated as the level of TDG that a
10191 specific group of fish would experience as they migrate, at depth, through the system. Table 3-63
10192 shows TDG conditions at Bonneville, McNary, and Chief Joseph dams. Modeling also shows that
10193 these fish would be exposed to an average TDG during migration of nearly 116 percent under the
10194 No Action Alternative. This value is relatively high, but current monitoring of similar values has
10195 not revealed high levels of injury or mortality (Table 3-64).

10196 **Table 3-63. Juvenile Model Metrics for Upper Columbia River Spring Chinook Salmon**
10197 **(Hatchery and Wild Fish Combined) under the No Action Alternative.**

Metric (Model)	NAA
Juvenile Survival (COMPASS) (McNary to Bonneville)	69.5%
Juvenile Travel Time (COMPASS) (McNary to Bonneville)	6.1 days
% Transported (COMPASS)	No upper Columbia River spring-run Chinook transported
Powerhouse Passages (COMPASS) (Rock Island to Bonneville)	3.29
TDG Average Exposure (TDG Tool) (McNary to Bonneville)	115.9% TDG

10198 **Table 3-64. Percent of Days with TDG above 120 Percent and 125 Percent at Bonneville,**
10199 **McNary, and Chief Joseph Dam, in the No Action Alternative.**

Project	% of days above 120% TDG	% of days above 125% TDG
Bonneville Dam	10.8	3.2
McNary Dam	6.8	2.1
Chief Joseph Dam	0.0	0.0

10200 *Adult Migration/Survival*

10201 Upstream passage survival estimates were not generated for adult salmon. However, the
10202 historic 10-year average survival estimate for upper Columbia River spring-run Chinook salmon
10203 from Bonneville to McNary Dam is 92 percent. These survival estimates account for total losses
10204 caused by the operation and existence of the dams and reservoirs, as well as any losses in these
10205 reaches resulting from any flow effects, temperature, disease, straying, or other natural causes
10206 (NMFS 2019). Columbia Basin spring-run Chinook salmon stray rates have consistently been less
10207 than 5 percent, though some case studies have had estimates ranging to more than 20 percent
10208 (Keefer and Caudill 2012). Adult migration success is not expected to change over time due to
10209 these factors under the No Action Alternative.

10210 The NWFSC LCM estimated that SARs for the Wenatchee upper Columbia River spring-run
10211 Chinook salmon population would be 0.94 percent under the No Action Alternative. As an index
10212 to compare the No Action Alternative to the MOs, the NWFSC LCM predicts that the median
10213 abundance of the Wenatchee population would be 498 adult fish returns.

10214 Prospective CSS cohort and lifecycle modeling was not available across MOs for the upper
10215 Columbia salmon populations. However, though not a representation of the No Action
10216 Alternative, the CSS calculated SARs for upper Columbia populations from their reconstructions
10217 of adult and juvenile population abundance trends at about 1 percent for Wenatchee
10218 population and two percent to three percent for the Methow population (Table 3-65).

10219 **Table 3-65. No Action Alternative Model Metrics for Adult Upper Columbia River Spring-Run**
10220 **Chinook Salmon**

Metric (Model)	NAA
SARs (NWFSC LCM – RIS to BON)	0.94
NWFSC LCM abundance	498

10221 Upper Columbia River Steelhead

10222 *Summary of Key Effects*

10223 COMPASS modeling estimates that juvenile upper Columbia steelhead survival from McNary
10224 Dam to Bonneville Dam would be 65.8 percent under the No Action Alternative. While no
10225 estimates of adult survival were generated; the ten-year average survival for adult upper
10226 Columbia River steelhead migrating upstream from Bonneville Dam to McNary Dam is 92
10227 percent.

10228 *Juvenile Migration/Survival*

10229 COMPASS model estimates of juvenile survival, travel time and powerhouse passage for upper
10230 Columbia River steelhead under the No Action Alternative are shown in Table 3-66. CSS
10231 modeling was not available for upper Columbia River steelhead.

10232 The predicted juvenile upper Columbia River steelhead survival of 65.8 percent for the No
10233 Action Alternative is within the range of observed data. Widener et al. (2018) estimated that
10234 the average hatchery-origin juvenile steelhead survival rates from McNary Dam tailrace to
10235 Bonneville Dam was 74 percent for 2008 to 2017. The method of estimating survival through
10236 this area of the Columbia River has been done historically with PIT tagged fish. Low PIT tag
10237 detection efficiencies at and below Bonneville Dam have resulted in increased variability
10238 around the average survival estimate, ranging from 49 to nearly 100 percent in 2008 to 2017.
10239 Similar to results for upper Columbia spring-run Chinook salmon, modeling for upper Columbia
10240 steelhead, shows they would be exposed to an average TDG during migration of over 115
10241 percent under the No Action Alternative. This value is relatively high, but current monitoring of
10242 similar values has not revealed high levels of injury or mortality.

10243 **Table 3-66. Juvenile Model Metrics for Upper Columbia River Steelhead (hatchery and wild**
10244 **fish combined) under the No Action Alternative.**

Metric (Model)	NAA
Juvenile Survival (COMPASS) (McNary to Bonneville)	65.8%
Juvenile Travel Time (COMPASS) (McNary to Bonneville)	6.6 days
% Transported (COMPASS)	No transport of upper Columbia steelhead

Metric (Model)	NAA
Powerhouse Passages (COMPASS) (Rock Island to Bonneville)	2.72
TDG Average Exposure (TDG Tool) (McNary to Bonneville)	116% TDG

10245 Predation on juvenile steelhead from the Upper Columbia River has been estimated in the
 10246 interior Columbia plateau at two managed sites, Goose Island (Potholes Reservoir) and Crescent
 10247 Island in the mainstem Columbia River. In the Potholes Reservoir, avian predation by Caspian
 10248 terns on upper Columbia River steelhead has declined from up to nearly 23 percent in 2009 to
 10249 approximately 4 percent in 2017 and has been eliminated at Crescent Island since management
 10250 actions commenced and loss of nesting habitat occurred in 2015 (Collis et al. 2018; Evans et al.
 10251 in press; Appendix E). As the number of nesting Caspian terns were reduced at Goose Island
 10252 and upstream at Crescent Island, there was an increase in abundance at Blalock Islands in the
 10253 John Day reservoir. This shift in abundance has generally increased avian predation rates on
 10254 juvenile steelhead in this reach, more specifically an increase in juvenile upper Columbia River
 10255 steelhead predation from less than one percent to up to eight percent. Similar predation rates
 10256 would be expected for upper Columbia River steelhead under the No Action Alternative.

10257 **Adult Migration/Survival**

10258 Upper Columbia steelhead would continue to experience upstream adult migration as
 10259 described in Section 3.5.2.1, *Common Effects to Salmon and Steelhead*.

10260 No life cycle modeling was completed for adult upper Columbia River steelhead. However, the
 10261 10-year average historic survival estimates for these fish, migrating upstream from Bonneville
 10262 Dam to McNary Dam, is 92 percent (range of 88 to 97 percent). In addition, substantial losses
 10263 (about 24 percent) of adult upper Columbia River steelhead appear to be occurring between
 10264 McNary and Priest Rapids dams. These survival estimates account for total losses caused by the
 10265 operations and existence of the dams and reservoirs, as well as any losses in these reaches
 10266 resulting from any flow effects, temperature, disease, or other natural causes (NMFS 2019).
 10267 Some of these losses may result from straying. However, most estimates of steelhead straying
 10268 in the Columbia River basin have been for Snake River summer-run populations. Median
 10269 straying estimates were typically between 3 to 10 percent, although some point estimates were
 10270 considerably higher (Bumgarner and Dedloff 2011; Keefer and Caudill 2012). Adult migration
 10271 success is not expected to change over time due to these factors under the No Action
 10272 Alternative.

10273 Downstream migration of iteroparous steelhead (i.e., steelhead that spawn more than one
 10274 time, also known as kelts) occurs from March through July (Keefer et. al. 2016). Kelt migration
 10275 can be affected by the extreme energetic demands of spawning and iteroparity, harvest, and
 10276 the Columbia River System (Colotelo et al. 2014) and non-federal dams. Normandeau et al.
 10277 (2014) conducted a direct survival adult steelhead balloon tagging study at McNary Dam and
 10278 found that mean survival of steelhead passing through the temporary spillway weirs was 98
 10279 percent and 91 percent through the turbine route, for overwintering adults presumed to be in

10280 good condition. As part of a two-year study, Colotelo et al. (2013) estimated that 67 percent
10281 survived from the McNary forebay to the Bonneville Dam face. See discussion of Snake River
10282 adult steelhead for an expanded discussion of the kelt research described above.

10283 Upper Columbia River Coho Salmon

10284 See upper Columbia spring-run Chinook salmon analysis as a surrogate for juvenile upper
10285 Columbia coho salmon. Upper Columbia fall Chinook salmon analysis is considered as a
10286 qualitative surrogate for adult Upper Columbia coho salmon.

10287 *Summary of Key Effects*

10288 The primary challenges for upper Columbia River coho salmon are the conditions they
10289 encounter during upstream and downstream migrations. Downstream survival and migration
10290 for juveniles is dependent on water flow and routing at the dams. Higher flows and higher spills
10291 generally lead to higher survival. See Upper Columbia River spring run Chinook salmon for
10292 estimated, surrogate measures of juvenile survival.

10293 Upper Columbia River Sockeye Salmon

10294 See Upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia River
10295 sockeye salmon.

10296 *Summary of Key Effects*

10297 The primary challenges for upper Columbia River sockeye salmon are the conditions they
10298 encounter during upstream and downstream migrations. Downstream survival and migration
10299 for juveniles is dependent on water flow and routing at the dams. Higher flows and higher spills
10300 generally lead to higher survival.

10301 For adults, the primary issue is high water temperatures during summer upstream migration.
10302 Upper Columbia sockeye salmon do not have significant hatchery influence so inferences would
10303 only apply to the naturally spawning population.

10304 After passing upstream of McNary Dam, adult upper Columbia sockeye migrate past three to
10305 five PUD owned dams and reservoirs that also impact the survival and passage of this species.
10306 The federal agencies do not dictate generation or spill levels at these projects so juvenile
10307 metrics such as powerhouse encounter rate are not directly affected but are influenced by river
10308 flow levels coming through the upper Basin. The timing and volume of flow levels affected by
10309 CRS operational decisions are reflected in model analysis from McNary to Bonneville and can be
10310 referenced for surrogate species, Upper Columbia River spring Chinook salmon.

10311 *Juvenile Migration/Survival*

10312 Juvenile travel time affects the upper Columbia River sockeye survival during this life stage.
10313 Upper Columbia River spring-run Chinook salmon survival is used as a surrogate for upper

10314 Columbia River sockeye. Under the No Action Alternative, juvenile sockeye are assumed to
10315 continue a similar survival rate with the same proportion of fish encountering powerhouses
10316 (e.g., the number of sockeye expected to pass through turbines and bypass systems would be
10317 similar to the number of upper Columbia River spring-run Chinook). Passage route selection in
10318 acoustic telemetry studies of upper Columbia River sockeye that were conducted by Grant
10319 County PUD support this statement (Timko et al. 2010, 2011).

10320 River flows can affect the downstream migration rate of juvenile sockeye. Looking at the low-
10321 flow conditions (in which 75 percent of years exceed the discharge) of April 15 through June 15
10322 when sockeye are migrating downstream, the discharge is approximately 208,000 cfs. In the No
10323 Action Alternative, the surrogate species of upper Columbia spring-run Chinook salmon may
10324 provide a conservative estimate of upper Columbia River sockeye salmon travel times. Acoustic
10325 telemetry studies have been conducted by the mid-Columbia River public utility districts and
10326 provide ancillary information, specifically Grant County PUD between 2006 and 2010, where
10327 they found that sockeye survived at a higher rate and traveled faster than yearling Chinook
10328 salmon and juvenile steelhead (Timko et al. 2011; Blue Leaf 2012). Survival of juvenile sockeye
10329 in reaches between Rock Island and McNary dams was higher in all reaches by a minimum of 5
10330 percent and a maximum of 15 percent when compared to yearling Chinook and juvenile
10331 steelhead migrating through the same reaches with similar run timing and passage histories.
10332 Travel times by juvenile sockeye in 2006-2010 through these reaches were also faster by
10333 approximately five days, compared to those modeled in the NAA alternative of surrogate
10334 species (e.g., 15 days by upper Columbia River yearling Chinook salmon).

10335 Juvenile sockeye are susceptible to predation by other larger fish during their downstream
10336 migration. Under the No Action Alternative, an unknown number of juvenile sockeye would be
10337 removed from the population by predators. Literature estimates that smallmouth bass, walleye,
10338 and northern pikeminnow remove large numbers of smolts. While it is difficult to measure and
10339 quantify losses of sockeye, temperature during outmigration can be used as a surrogate for
10340 estimating risk of loss to predators. The mean water temperature from April 15 through May 31
10341 at McNary Dam is 1200°C under the No Action Alternative and can be used for comparisons of
10342 qualitative increases or decreases in predation risk for the MOs in relation to the No Action
10343 Alternative.

10344 Avian predation on juvenile salmon is another important factor of surviving their outmigration.
10345 Predation rates on juvenile upper Columbia River sockeye are not well documented; however,
10346 since 2010, predation rates by the Caspian tern nesting colony at the Blalock Islands Complex
10347 on Snake River sockeye has averaged one percent (Evans et al. in press). Nesting habitat and
10348 avian predation rates would remain the same under the No Action Alternative and therefore
10349 predation rates should remain similar (one percent or less).

10350 TDG during the migration period can affect juvenile and adult sockeye in the form of GBT; the
10351 condition is more stressful for juvenile fish, which are more susceptible because they tend to
10352 swim at shallower mean depths (Backman and Evans 2002). The No Action Alternative is

10353 expected to continue at the same rate as presently occurs each year and similar to the
10354 surrogate species, upper Columbia River spring-run Chinook salmon.

10355 *Adult Migration/Survival*

10356 See the Effects Common across Salmon and Steelhead section (Section 3.5.2.4), for an overview
10357 of adult migration/survival effects on salmon and steelhead under the No Action Alternative.

10358 Higher water temperatures correspond to lower adult survival during upstream migration and
10359 survival can be less than 50 percent when water temperature is greater than 18°C. When the
10360 Okanogan River gets to 21° to 22°C, fish stop moving into the river; survival then depends on
10361 temperatures in the Columbia River where they hold in refuge. The migration period is early
10362 June through mid-August; therefore, the important metric is the percentage of days the daily
10363 mean temperature exceeds 18°C at McNary and Chief Joseph Dams. Recent data shows McNary
10364 Dam has 72.4 percent of days in this period above 18°C and Chief Joseph Dam has 24.9 percent
10365 of days above 18°C. These conditions are expected to continue under the No Action Alternative
10366 and have adverse effects to the species when present. Survival is expected to continue to be
10367 less than 50 percent during years that are warmer than average.

10368 Upper Columbia River Summer/Fall-Run Chinook Salmon

10369 *Summary of Key Effects*

10370 Key effects to upper Columbia summer/fall-run Chinook salmon include high predation rates of
10371 juvenile fish and elevated water temperatures during adult upstream migration. An estimated
10372 50 percent of all juvenile Chinook salmon do not survive from Priest Rapids Dam to McNary
10373 Dam (Harnish et al. 2014). These fish are lost through predation by birds or other fish. In
10374 addition, elevated water temperatures can delay adult migration. Water temperatures
10375 currently reach over 68°F approximately 1 in 3 days during the summer/fall migration.

10376 *Larval Development/Juvenile Rearing*

10377 Adequate spawning habitat is limited in the Columbia River. The Vernita Bar, located
10378 downstream of Priest Rapids Dam, is a critical spawning site for upper Columbia summer/fall-
10379 run Chinook salmon in the Columbia River. Water level management is important for spawning
10380 in this reach and can have adverse effects if water levels are dropped by desiccating eggs or
10381 stranding fry. An agreement called the Vernita Bar Agreement was reached in 2004 and
10382 maintains a minimum outflow of 70,000 cfs to guarantee adequate spawning habitat for
10383 Chinook salmon below Priest Rapids Dam during spawning and incubation. To evaluate effects
10384 to spawning habitat, investigators calculated the frequency of meeting the Vernita Bar
10385 Agreement. Under the No Action Alternative, the agreement is met in all years.

10386 Water quality is important for egg and fry incubation and development. Specifically, water
10387 temperatures over 68°F and TDG over 120 percent were selected as metrics to evaluate
10388 adverse effects to early life stages of Chinook salmon. The frequency of days that exceeded

10389 these values were used to evaluate effects. Under the No Action Alternative, no days were
10390 projected with values for temperature or TDG would exceed critical levels.

10391 *Juvenile Migration/Survival*

10392 Compared with yearling Chinook and steelhead, subyearling fall Chinook typically migrate
10393 deeper in the water column and are less likely to use surface spillway routes. An estimated 50
10394 percent of juvenile upper Columbia summer/fall-run Chinook salmon are lost before they reach
10395 McNary Dam to birds or other predators (Harnish et al. 2014). Water temperature can affect
10396 juvenile salmon survival via predation. As temperatures increase, aquatic predators become
10397 more active and metabolic demands increase. Consequently, risk to predation for juvenile
10398 salmon increases. To analyze potential effects of MOs, an increase or decrease in water
10399 temperatures during migration was used as a surrogate for predation risk. To measure effects
10400 to predation risk, the number or percent of days, May through August, with mean
10401 temperatures over 20°C was used to compare MOs. Currently, water temperatures exceed 20°C
10402 approximately 42 percent of the time. These water temperatures would impact juvenile
10403 Chinook salmon survival through the mechanisms listed above; however, it is unknown what
10404 total number of these fish are lost to predation. The No Action Alternative is expected to
10405 continue the existing conditions.

10406 Avian predation on juvenile salmon is another important factor impacting their surviving during
10407 outmigration. Snake River fall-run Chinook salmon predation rates from avian predators at East
10408 Sand Island ranged from 0.7 to 3.4 percent for Caspian terns and from 1.6 to 8.7 percent for
10409 Double Crested Cormorants (Evans et al. 2018). Similar rates of predation are expected for
10410 upper Columbia River summer/fall-run Chinook salmon. Nesting habitat for birds would remain
10411 the same under the No Action Alternative.

10412 During juvenile outmigration, instances of higher turbidity can decrease predation rates
10413 because reduced clarity of water hides juveniles so their susceptibility to predation decreases.
10414 The No Action Alternative is expected to have no changes to timing and duration of higher
10415 turbidity.

10416 *Adult Migration/Survival*

10417 The frequency that water temperatures at McNary Dam exceeded 20°C July through November
10418 was used as a measure of potential migration delay for upper Columbia River summer/fall-run
10419 Chinook salmon. In the No Action Alternative, over 34 percent of days between July and
10420 November would be over 20°C. Most of these days occur in July and August. Adult summer run
10421 Chinook typically migrate from the start of June through early August, and the tail end of the
10422 run may continue to be affected by elevated temperatures in late July and August. The start of
10423 the fall Chinook migration typically starts in August when temperatures still exceed 20°C, and
10424 peaks in September when temperatures decline.

10425 During upstream migration, a temperature difference of more than 2°C in the fish ladders
10426 compared to river water can delay adult migration. Water temperature differentials at the fish

10427 ladders are most concerning June through September when elevated temperatures are most
10428 likely to create differences that may lead to adult migration delays. At McNary Dam, less than 3
10429 percent of days from June through September would have ladder differentials greater than 2°C.
10430 Under the No Action Alternative, these limited events are expected to continue.

10431 Other water quality parameters include sediment levels measured in total suspended solids and
10432 DO concentrations. Both parameters are measured in milligrams per liter (mg/L). The average
10433 sediment concentrations in current conditions are approximately 2 mg/L and no change is
10434 anticipated in the No Action Alternative. The typical DO concentrations in the Snake River are
10435 between 9.5 and 11 mg/L, which poses no trouble for fish species. Under the No Action
10436 Alternative, no adverse effects are expected from the oxygen concentrations.

10437 ***Middle Columbia River Salmon and Steelhead***

10438 Middle Columbia River Spring Chinook Salmon

10439 See quantitative results from the Upper Columbia River Spring Chinook analysis as a surrogate
10440 for Middle Columbia River Spring Chinook Salmon.

10441 *Summary of Key Effects*

10442 Middle Columbia River spring Chinook salmon are not ESA-listed and limited migration/survival
10443 data exists. The primary challenges for middle Columbia River spring Chinook salmon are the
10444 conditions they encounter during upstream and downstream migrations. Downstream survival
10445 and migration for juveniles is dependent on water flow and routing at the dams. Higher flows
10446 and higher spills generally lead to higher survival. See Upper Columbia River spring Chinook
10447 salmon for estimated, surrogate measures of juvenile survival. Middle Columbia River spring
10448 Chinook salmon would experience similar survival rates, although they traverse a shorter
10449 distance than their upper Columbia River counterparts, they pass the same dams from McNary
10450 to Bonneville Dam and their juvenile and adult migration timing and survival would be similar.

10451 Middle Columbia River Steelhead

10452 Refer to upper Columbia River steelhead analysis as a surrogate for middle Columbia River
10453 steelhead.

10454 *Summary of Key Effects*

10455 Key effects for middle Columbia River steelhead include delays during upstream adult migration
10456 from elevated water temperature and reduced survival during downstream migration, similar
10457 to the results of surrogate species, upper Columbia River steelhead.

10458 *Juvenile Migration/Survival*

10459 Middle Columbia River steelhead would experience similar survival rates under the No Action
10460 Alternative. Although middle Columbia River steelhead traverse a shorter distance than their

10461 surrogate, upper Columbia River steelhead, they pass the same federal dams from McNary Dam
10462 to Bonneville Dam. Because effects to middle Columbia River steelhead were not modeled,
10463 upper Columbia River steelhead were used as a surrogate species to evaluate effects of MOs on
10464 middle Columbia

10465 Predation on juvenile steelhead from the middle Columbia River has not been estimated in the
10466 interior Columbia plateau; however, predation rates would be similar to upper Columbia River
10467 steelhead under the No Action Alternative. Refer to the results of Upper Columbia Steelhead as
10468 a surrogate for Middle Columbia River Steelhead.

10469 *Adult Migration/Survival*

10470 No smolt to adult return rates were calculated for upper or middle Columbia River steelhead.
10471 Refer to the results of Upper Columbia Steelhead as a surrogate for Middle Columbia River
10472 Steelhead.

10473 Each summer, when the mainstem Columbia River temperature increases to above 18°C, a
10474 large portion of middle Columbia River steelhead seek cool water temperature refuge in cooler
10475 tributaries such as the Little White Salmon, White Salmon, or Deschutes Rivers, or in
10476 deeper/cooler mainstem areas within the Columbia River. In July and August, during the peak
10477 of the middle Columbia River steelhead adult migration, the sun warms the water in the top
10478 portion of the reservoirs, which can lead to high temperatures and water temperature
10479 differences in the fish ladders. Ladder temperatures exceeding 20°C and water temperature
10480 differences greater than 1.8 degrees Fahrenheit have been demonstrated to cause delay in
10481 steelhead and can reduce their successful migration to the streams in which they were born
10482 (Caudill et al. 2013). Ladder temperatures commonly exceed 20°C and ladder differentials
10483 regularly exceed 1.8 degrees Fahrenheit while middle Columbia River steelhead are migrating
10484 (McCann 2018). During the most extreme summer days, ladder temperatures in CRS dams can
10485 exceed 75.0°F, and ladder differentials can exceed 4.5 degrees Fahrenheit (FPC 2019). This
10486 would continue under the No Action Alternative.

10487 A proportion of middle Columbia River steelhead from the John Day major population group
10488 (MPG) do not enter the John Day River in the summer, likely because of elevated water
10489 temperatures. Based on PIT detections, many of these fish migrate past the John Day River in
10490 the summer and overshoot McNary Dam, presumably to find cooler water until the John Day
10491 River cools. A large portion of these fish do not attempt to migrate back downstream through
10492 McNary Dam until after prescribed spill has ended in August, and a smaller portion do not
10493 attempt downstream migration until after the juvenile bypass system has shut down in mid-
10494 November. Some of these fish overwinter in the McNary Reservoir or further upstream. This
10495 leaves the turbines as the only available passage route for many of these fish, which is the
10496 lowest survival route for adult steelhead. Research conducted since the implementation of the
10497 2008 FCRPS Biological Opinion has demonstrated the spillway weir is the most effective and
10498 safe route to pass adult steelhead at McNary Dam. Normandeau et al. (2014) conducted an
10499 adult steelhead balloon tagging study at McNary Dam and found that 98.0 percent of the
10500 steelhead passing the temporary spillway weir survived and were injury-free. The fish passed

10501 through the turbine unit had significantly lower survival (91 percent) and more life-threatening
10502 injuries, presumably caused by blade strike and shear forces. Colotelo et al. (2013) also found
10503 that the survival of adult steelhead kelts through spillways and surface weirs was high (>95
10504 percent), and survival through turbine units was lower (<80 percent), indicating that overshoots
10505 survive at a higher rate when spill protection is provided when they migrate back downstream.

10506 Downstream migration of iteroparous steelhead (i.e. steelhead that spawn more than one time,
10507 also known as kelts) occurs from March through July (Keefer et. al, 2016). Kelt migration can be
10508 affected by the extreme energetic demands of spawning and iteroparity, harvest, and the
10509 Columbia River System (Colotelo et al. 2014) and non-federal dams. Normandeau et al. (2014)
10510 conducted a direct survival adult steelhead balloon tagging study at McNary Dam and found
10511 that mean survival of steelhead passing through the temporary spillway weirs was 98 percent
10512 and 91 percent through the turbine route, for overwintering adults presumed to be in good
10513 condition. As part of a two-year study, Colotelo et al. (2013) estimated that 67 percent survived
10514 from the McNary forebay to the Bonneville Dam face.

10515 Predation effects to summer migrating adult middle Columbia River steelhead are likely
10516 relatively small because pinniped numbers are generally low in July and August, when most
10517 middle Columbia River steelhead pass Bonneville Dam, and the steelhead are mixed with
10518 relatively abundant fall-run Chinook salmon migrating in September and October.

10519 ***Snake River Salmon and Steelhead***

10520 Snake River Spring/Summer-Run Chinook Salmon

10521 *Summary of Key Effects*

10522 COMPASS and CSS modeling estimates of juvenile Snake River spring/summer-run Chinook
10523 salmon survival range from 50.4 to 57.6 percent, respectively, with substantially different
10524 estimates for the number of Snake River spring/summer-run Chinook salmon that would be
10525 transported. The two models also predict significantly different smolt-to-adult return rates.

10526 *Juvenile Migration/Survival*

10527 COMPASS and CSS cohort models both provide estimates of juvenile survival metrics
10528 (Table 3-67). Results below reflect combined natural and hatchery origin juvenile Snake River
10529 spring/summer Chinook salmon in-river survival. It is important to note that hatchery Snake
10530 River spring-run Chinook salmon have about 15 percent higher in-river survival rate than
10531 natural origin Snake River spring-run Chinook, but Snake River summer-run Chinook salmon for
10532 both hatchery and natural origin juveniles have similar in-river survival rates (Buchanan et al.
10533 2010). The COMPASS and CSS cohort model estimates are reported as the average value based
10534 on the 80-year water record estimates for both hatchery and natural origin fish. The values are
10535 provided below, but these metrics are best used for relative comparison purposes between
10536 MOs.

10537 **Table 3-67. Juvenile Model Metrics for Snake River Spring/Summer Chinook Salmon**
10538 **(Hatchery and Wild Fish combined) under the No Action Alternative.**

Metric (Model)	NAA
Juvenile Survival (COMPASS)	50.4%
Juvenile Survival (CSS)	57.6%
Juvenile Travel Time (COMPASS)	17.7 days
Juvenile Travel Time (CSS)	15.8 days
Juveniles Transported (COMPASS)	38.5%
Juveniles Transported (CSS)	19.2%
Juvenile Transport: In-River Benefit Ratio (CSS)	0.86
Juvenile Powerhouse Passages (COMPASS)	2.25
Juvenile Powerhouse Passages (CSS)	2.15
TDG Average Exposure (TDG Tool)	115.1%

10539 All Estimates are from Lower Granite Dam to Bonneville Dam.

10540 For comparison with historic survival rates, Widener et al. (2018) estimated that juvenile Snake
10541 River spring-run/summer Chinook salmon survival rates (wild and hatchery combined) from
10542 Lower Granite to Bonneville Dam averaged 53 percent (ranging from 44 to 64 percent) for the
10543 same time period. These survival rates incorporate multiple sources of mortality such as passage
10544 mortality, natural mortality, and predation (NMFS 2019).

10545 Juvenile fish transportation is also a factor in returning adult conversion rate as fish pass back
10546 up through the CRS years later, though other factors such as temperature, spill, and catch are
10547 more important to upstream system survival (Crozier et al. 2016). Overall, transported Snake
10548 River spring/summer-run Chinook salmon tend to have relatively low rates of straying (Gosselin
10549 et al. 2018).

10550 Wild yearling Chinook salmon tend to have the lowest transport benefit, and hatchery yearling
10551 Chinook salmon and hatchery steelhead tend to have higher benefits from transport. In
10552 addition, fish transported later in the year generally show greater benefits from being
10553 transported late and to transporting hatchery fish. For the No Action Alternative, CSS cohort
10554 modeling predicts a season-wide Transport:In-River benefit ratio for natural origin yearling
10555 Chinook salmon of 0.86 for comparison with alternatives. However, season wide TIR ratios can
10556 be misleading as benefits of transport vary within season. For example, in most years,
10557 beginning in May, adult returns are higher for transported spring summer Chinook than for in
10558 river fish (Smith et al. 2013).

10559 *Adult Migration/Survival*

10560 See the Effects Common across Salmon and Steelhead section, Section 3.5.2.2, No Action
10561 Alternative, for an overview of adult migration/survival effects on salmon and steelhead under
10562 the No Action Alternative.

10563 The 10-year average (2008 to 2017) minimum survival estimate for hatchery and natural origin
10564 Snake River spring/summer-run Chinook salmon from Bonneville to McNary Dam is 89 percent,

10565 with range of 83 to 100 percent, and from Bonneville to Lower Granite Dam is 84 percent, with
10566 range of 77 to 94 percent (NMFS 2019). These survival estimates account for total losses from
10567 the dams and reservoirs, as well as any losses in these reaches resulting from any flow effects,
10568 temperature, disease, or other natural causes (NMFS 2019).

10569 Columbia Basin spring-run Chinook salmon stray rates have consistently been less than 5
10570 percent, though some case studies have had estimates ranging to more than 20 percent (Keefer
10571 and Caudill 2012). Adult migration success is not expected to change over time due to these
10572 factors under the No Action Alternative.

10573 For Snake River spring/summer-run Chinook salmon specifically, seal and sea lion presence in
10574 the Columbia River appears to coincide with salmon upstream migration timing (Tidwell et al.
10575 2017). While pinniped injury to some degree adversely affects conversion to spawning
10576 tributaries, pinniped-caused injury rates decrease as annual run sizes increase, indicating
10577 density dependent or saturation effects in some years (Naughton et al. 2011). Pinniped
10578 predation rates are expected to continue to increase under the No Action Alternative.

10579 Under the No Action Alternative, SARs for Snake River spring/summer-run Chinook salmon were
10580 estimated at 0.88 and 2.00 for NMFS and the Fish Passage Center models, respectively
10581 (Table 3-68). These numbers are similar to values observed in recent years for this species.
10582 Overall Lower Granite to Bonneville SARs for wild Snake River Chinook with jacks included have
10583 ranged from 0.30 to 4.13 (arithmetic mean of 1.32 percent) between 2000-2016 (Table B.2, 2018
10584 Final CSS Report).

10585 **Table 3-68. Model Metrics Related to Adult Survival and Abundance of Snake River**
10586 **Spring/Summer Chinook Salmon under the No Action Alternative**

Metric (Model)	NAA
LGR-BON SARs (NWFSC LCM)	0.88
LGR-BON SARs (CSS)	2.0
NWFSC LCM abundance	2,351
Abundance (CSS) ^{1/}	6,114

10587 1/ CSS provided results for six populations in the Grande Ronde/Imnaha Major Population Group. The
10588 absolute values represent those populations only.

10589 Snake River Steelhead

10590 *Summary of Key Effects*

10591 Modeled estimate of in-river survival is near the recent observed survival rates of juvenile
10592 Snake River steelhead between Lower Granite Dam and Bonneville Dam, which were estimated
10593 on average at 56 percent from 2008 to 2017. Over the same period, the average upstream
10594 survival for these adult fish from Bonneville Dam to McNary Dam was 94 percent, and survival
10595 from Bonneville Dam to Lower Granite Dam was 87 percent. Juvenile transport continues to
10596 show an overall benefit for Snake River steelhead. However, the degree of benefit has

10597 decreased as in-river survival has increased. Additionally, the proportion of fish being
10598 transported has steadily declined since 2008.

10599 *Juvenile Migration/Survival*

10600 Survival of juvenile Snake River steelhead from Lower Granite to Bonneville Dam is estimated at
10601 42.7 and 57.1 percent for COMPASS and CSS modeling, respectively (Table 3-69). By
10602 comparison, Widener et al. (2018) estimated historic juvenile Snake River steelhead survival
10603 rates (wild and hatchery combined) from 2008 to 2017 for this same reach at 56 percent. These
10604 survival rates incorporate multiple sources of mortality, such as passage mortality, natural
10605 mortality, and predation (NMFS 2019).

10606 **Table 3-69. Juvenile Model Metrics for Snake River Steelhead under the No Action Alternative**

Metric (Model)	NAA
Juvenile Survival (COMPASS)	42.7%
Juvenile Survival (CSS)	57.1%
Juvenile Travel Time (COMPASS)	16.4 days
Juvenile Travel Time (CSS)	16.2 days
Transported (COMPASS)	39.7%
Transported (CSS)	Unknown
Transport:In-River Benefit Ratio (CSS)	1.41
Powerhouse Passages (COMPASS)	1.73
Powerhouse Passages (CSS)	1.96
TDG Average Exposure (TDG Tool)	115.1 % TDG

10607 The effectiveness of the juvenile fish transportation program is evaluated annually, and juvenile
10608 transport continues to show an overall benefit for Snake River steelhead. However, the degree
10609 of benefit has decreased as in-river survival has increased and the proportion of fish being
10610 transported has decreased subsequent to the increase in spill and the later transport collection
10611 dates that were implemented for juvenile yearling spring-run Chinook salmon and steelhead in
10612 2006 (NMFS 2019). The experience of transportation as juveniles is a factor influencing
10613 conversion rate of returning adults as fish pass back up through the CRS years later, especially
10614 for natural origin steelhead (Keefer et al. 2008). Recent transport rates (2008 to 2017) have
10615 averaged 34 and 32 percent for wild and hatchery Snake River steelhead, respectively (NMFS
10616 2019). For No Action Alternative modeling, the transportation start date was April 25 under the
10617 *Juvenile Fish Transportation in the Columbia and Snake Rivers* measure. CSS cohort modeling
10618 estimated the average season-wide transport to in-river SAR ratio (TIR) for Snake River
10619 steelhead at 1.41 for comparison to MOs, based on both hatchery and natural origin fish.
10620 However, season wide TIR values can be misleading as the benefits of transport vary within
10621 season, where fish transported later in the year generally show greater benefits from being
10622 transported.

10623 *Adult Migration/Survival*

10624 The historic 10-year average (2008 to 2017) minimum survival estimate for Snake River
10625 steelhead adults from Bonneville Dam to McNary Dam was 94 percent, with range of 90 to 100
10626 percent, and the minimum survival estimate from Bonneville Dam to Lower Granite Dam was
10627 87 percent, with range of 81 to 94 percent (NMFS 2019). Most estimates of steelhead straying
10628 in the Columbia River basin have been for Snake River summer-run populations. Median
10629 straying estimates for Snake River steelhead are typically between 3 to 10 percent, although
10630 some point estimates were considerably higher (Bumgarner and Dedloff 2011; Keefer and
10631 Caudill 2012). Adult migration success is not expected to change over time under the No Action
10632 Alternative, but Chapter 4 discusses anticipated effects of climate change.

10633 For Snake River steelhead specifically, Steller sea lions in particular aggregate at the base of
10634 Bonneville Dam in the fall when Snake River steelhead are present. Adjusted consumption
10635 estimates for all steelhead at the tailrace of Bonneville Dam by pinnipeds is 1.5 percent (Tidwell
10636 et al. 2018). Based on the timing of the observations in the study, NMFS (2019) stated that 1.5
10637 percent is a reasonable estimate for Snake River steelhead mortality due to pinnipeds.

10638 Migration of iteroparous steelhead (kelts) occurs from March through July (Keefer et. al, 2016).
10639 Migration success rates from Lower Granite Dam to downstream of Bonneville Dam was
10640 estimated at 4.1 and 15.6 percent in 2001 and 2002, respectively (Wertheimer and Evans,
10641 2005). These estimates represent total mortality to outmigrating kelts and were derived in a
10642 low flow year with very little spill (2001) and a more normal flow year with spill (2012). In 2013,
10643 Colotelo et al. (2014) estimated that 27 percent of kelt migrated successfully from Lower
10644 Granite Dam to below Bonneville Dam. The majority of kelts utilized spillways and surface flow
10645 outlets to pass dams when those routes were available. For example, Rayamajhi et al. (2013)
10646 estimated fish passage efficiency (passage routes other than turbines) at 91 and 84 percent in
10647 2013 at The Dalles and Bonneville Dams, respectively. At both projects passage survival through
10648 spillways and surface flow outlets was estimated in the low 90s while turbine passage survival
10649 was estimated in the low70s. Normandeau et al. (2014) conducted an adult steelhead balloon
10650 tagging study at McNary Dam and found that 98 percent of the steelhead passing the
10651 temporary spillway weirs were injury-free. The fish released through the turbine unit had more
10652 life-threatening injuries, presumably caused by blade strike and shear forces. Colotelo et al.
10653 (2013) also found that the survival of adult steelhead kelts through spillways and surface weirs
10654 was high (greater than 95 percent) and survival through turbine units was lower (less than 80
10655 percent), indicating that kelts and potentially steelhead overshoots survive at a higher rate
10656 when spill protection is provided when they migrate back downstream.

10657 Table 3-70 displays the CSS model results for Snake River steelhead. NWFSC LCM modeling for
10658 Snake River steelhead was not available. Overall Lower Granite to Bonneville SARs for wild
10659 Snake River steelhead have ranged from 0.25 to 3.95 (arithmetic mean of 2.03 percent)
10660 between 2006-2015 (Table B.36, 2018 Final CSS Report).

10661 **Table 3-70. Model Metrics Related to Adult Survival and Abundance of Snake River Steelhead**
10662 **under the No Action Alternative**

Metric (Model)	NAA
SARs LGR-LGR (CSS)	1.8

10663 Snake River Coho Salmon

10664 See Snake River spring/summer-run Chinook as a surrogate for juvenile Snake River coho
10665 salmon and Snake River fall-run Chinook as a surrogate for adult Snake River coho salmon.

10666 *Summary of Key Effects*

10667 The primary effects for Snake River coho salmon involve both downstream and upstream
10668 passage through eight Federal dams and their reservoirs. Changes in dam reservoir
10669 environments in the Snake River may affect the susceptibility of Snake River juvenile coho
10670 salmon to fish-eating predators (e.g., channel catfish, walleye, pikeminnow, and smallmouth
10671 bass), which become more active at warmer water temperatures.

10672 Snake River Sockeye Salmon

10673 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake
10674 River sockeye salmon.

10675 *Summary of Key Effects*

10676 The primary issues for Snake River sockeye salmon are the conditions encountered during
10677 upstream and downstream migrations. Longer downstream juvenile migration passage and
10678 timing at projects put sockeye salmon at risk for effects associated with higher water
10679 temperatures, predation, or physical effects over a longer period than historically occurred. For
10680 adult sockeye salmon, the primary issue is high water temperatures.

10681 *Juvenile Migration/Survival*

10682 Data for Snake River spring/summer run Chinook salmon were used as a surrogate for Snake
10683 River sockeye salmon to analyze survival and travel time. Snake River sockeye salmon typically
10684 display faster travel times and migrate at a deeper depth than Chinook salmon, so they likely
10685 experience shorter travel times than those estimated by the surrogate species, under the No
10686 Action Alternative. Studies conducted by the middle Columbia River PUDs have also found
10687 juvenile sockeye to migrate at faster rates than yearling Chinook salmon (Timko et al. 2011;
10688 Blue Leaf 2012). Refer to the Snake River spring/summer-run Chinook salmon analysis as a
10689 surrogate for Snake River sockeye salmon in Section 3.5.3.2.

10690 Spill affects juvenile migration routes through the projects under the *Spill Operations to*
10691 *Improve Juvenile Passage* measure of the No Action Alternative. Increased spill generally
10692 reduces travel time as fish find spill routes more readily than turbine routes. Additionally, more

10693 spill generally means fewer powerhouse encounters, which would increase survival by not
10694 going through turbines. Snake River sockeye salmon are assumed to have similar survival rates
10695 and powerhouse encounter rates as Snake River spring/summer run Chinook salmon under the
10696 No Action Alternative.

10697 Under the No Action Alternative, approximately 65,000 (11 percent) Snake River sockeye
10698 salmon would be transported annually through the *Juvenile Fish Transportation in the Columbia
10699 and Snake Rivers* measure. Because there are relatively few studies that evaluate the benefits
10700 of transportation for Snake River sockeye salmon, there is less certainty regarding the effects of
10701 these operations.

10702 TDG during the migration period can affect juvenile and adult Snake River sockeye salmon in
10703 the form of GBT. The parameter of concern is the number of days over 120 and 125 percent at
10704 Bonneville, McNary, and Lower Granite dams (Table 3-71). The No Action Alternative is
10705 expected to continue with similar rates to observed data.

10706 **Table 3-71. Percent of Days with TDG above 120 Percent and 125 Percent in the No Action**
10707 **Alternative**

Project	% of days above 120% TDG	% of days above 125% TDG
Bonneville Dam	10.8	3.2
McNary Dam	6.8	2.1
Lower Granite Dam	2.7	1.3

10708 Juvenile Snake River sockeye salmon are susceptible to predation by other larger fish during
10709 their downstream migration. Literature estimates indicate that smallmouth bass, walleye, and
10710 northern pikeminnow remove large numbers of sockeye salmon smolts. However, under the No
10711 Action Alternative, it is difficult to measure and quantify these effects to Snake River sockeye
10712 salmon. Temperature during outmigration is sometimes used as a surrogate for estimating risk
10713 of loss to predators. However, the mean water temperature from April 15 to May 31 at McNary
10714 Dam is only 12.03°C and is unlikely to increase the metabolic rates of predators that eat more
10715 migrating smolts due to increased food needs associated with the higher water temperatures.
10716 Changes in predation rates under the No Action Alternative are not expected.

10717 Avian predation on juvenile salmon is another important factor of surviving their outmigration.
10718 Roby et al. (2017) estimated avian predation of Snake River sockeye salmon at 5.9 percent.
10719 These rates are not expected to change under the No Action Alternative.

10720 *Adult Migration/Survival*

10721 See the Effects Common across Salmon and Steelhead section, under Section 3.5.2.2, for an
10722 overview of adult migration/survival effects on salmon and steelhead under the No Action
10723 Alternative.

10724 Historic returns for Snake River sockeye salmon are so variable that the analysis used Snake
10725 River spring/summer-run Chinook salmon as a surrogate for Snake River sockeye salmon. For

10726 analysis of life cycle models and a description of potential latent effects of the CRS, refer to the
10727 Snake River spring/summer-run Chinook salmon section of the No Action Alternative.

10728 Recent Snake River sockeye adult survival rates (2013 to 2017) from Bonneville Dam to McNary
10729 Dam have averaged about 60 percent, and adult survival from Bonneville Dam to Lower Granite
10730 Dam has averaged about 50 percent (NMFS 2019). These survival estimates account for total
10731 losses from all sources, including from effects from the dams and reservoirs, flow, temperature,
10732 disease, or other natural causes. Estimated survival rates for PIT-tagged sockeye salmon from
10733 Lower Granite dam to Redfish Lake, the Sawtooth Hatchery weir, or other locations vary from
10734 just over 0 percent to greater than 70 percent depending on water conditions and migration
10735 timing of a given year (Johnson et al. 2017). In addition, earlier fish survive at higher rates and
10736 fish that pass Lower Granite Dam after the first week in July generally do not survive to reach
10737 the Sawtooth Valley (Crozier et al. 2014; NMFS 2019). Adult migration success is not expected
10738 to change over time due to these factors under the No Action Alternative.

10739 To reach Redfish Lake and their home spawning areas, this population of fish swims upstream
10740 more than 900 miles with an elevation gain of over 6,500 feet. Along this route, Snake River
10741 sockeye salmon encounter eight dams. Adult Snake River sockeye salmon encounter upstream
10742 migration difficulties in the form of reduced homing ability if they were transported
10743 downstream as juveniles, as well as high water temperatures and TDG levels. The water
10744 temperature differential between river water and fish ladder water can often make sockeye
10745 salmon hesitate to enter and ascend the ladders.

10746 Adult sockeye salmon that were transported downstream as juveniles exhibit a higher rate of
10747 fallback (i.e., salmon that pass two or more times the same project on the same day or on a
10748 later day), reduced homing ability, and longer migration time on their upstream migration
10749 compared to the fish that migrated in-river as juveniles. This causes a longer adult upstream
10750 migration time, which takes more energy and can reduce fitness for spawning once the
10751 destination is reached. Approximately 39 percent of juveniles are transported, and transported
10752 sockeye salmon are 2.9 times more likely to fall back and experience delay as adults (Crozier et
10753 al. 2015). This rate is expected to continue under the No Action Alternative.

10754 Higher water temperatures correspond to lower adult survival. Adult survival rate has been less
10755 than 50 percent when water temperature is greater than 18°C measured at Bonneville Dam.
10756 High temperatures can also cause delays in upstream migration. Under the No Action
10757 Alternative, temperatures would exceed 18°C at Ice Harbor approximately 78 percent of all
10758 days during the sockeye salmon migration (June 21 to July 31).

10759 During upstream migration, a temperature differential of more than 2°C in the fish ladders
10760 compared to river water can delay adult migration. During adult migration (June 21 to July 31),
10761 approximately 50.1 percent of all days have a temperature differential greater than 2°C. This
10762 would continue under the No Action Alternative.

10763 Other water quality parameters include sediment levels measured in total suspended solids and
10764 DO concentrations. Both parameters are measured in mg/L. The average sediment

10765 concentrations in current conditions are approximately 2 mg/L and no change is anticipated in
10766 the No Action Alternative. The typical DO concentrations in the Snake River are between 9.5
10767 and 11 mg/L, which poses no adverse effect for fish species. Under the No Action Alternative,
10768 no adverse effects are expected from the oxygen concentrations.

10769 Snake River Fall-Run Chinook Salmon

10770 *Summary of Key Effects*

10771 Unlike most other ESUs discussed, Snake River Fall Chinook salmon spawn within the mainstem
10772 of the Snake River; therefore, the area that would be directly impacted by the operation of CRS
10773 projects could impact larval development and juvenile rearing.

10774 *Larval Development/Juvenile Rearing*

10775 For eggs to develop properly in their gravel nests, called redds, the adult spawners must have
10776 access to acceptable sizes of spawning gravel; the appropriate gravel size allows for water to
10777 bring in oxygen and clear wastes from the embryos until they grow to fry size and emerge from
10778 the gravel. Suitable sediment sizes for spawning are between 1 and 6 inches (Geist and Dauble
10779 1998). Within the lower Snake River, fall Chinook spawning habitats are limited to tailwater
10780 areas of each of the four lower Snake River dams and sections of the Clearwater and Snake
10781 River above Lower Granite Dam. Under the No Action Alternative, spawning sites are not
10782 expected to change.

10783 Some juvenile Chinook salmon that originate in the Clearwater River use reservoirs as rearing
10784 habitat and overwinter in reservoirs before migrating downstream as yearlings. Under the No
10785 Action Alternative, all reservoirs that support this life history type would continue to provide
10786 juvenile rearing habitat.

10787 *Juvenile Migration/Survival*

10788 Temperature affects juvenile salmon survival via predation, increased energetic requirements,
10789 and susceptibility to disease (e.g., columnaris). During the juvenile outmigration period,
10790 concentrations of juvenile salmonids at dam structures make them more susceptible to
10791 predators that are larger fish (e.g., channel catfish, walleye, pikeminnow, and smallmouth
10792 bass), which become more active at warmer water temperatures. The threshold for higher risk
10793 is thought to be 20°C, but these predators become active at even cooler temperatures. To
10794 analyze potential effects to juvenile from predation, an increase or decrease in mainstem
10795 temperatures during migration is used as a surrogate for predation risk. Average temperature
10796 at Ice Harbor Dam between May and July is measured and the risk index is calculated as the
10797 percent of days over 20°C. The Snake River's mainstem water temperatures have a mean
10798 temperature of 16.5°C and 26.6 percent of days over 20°C. Current water temperatures have
10799 minor effects to juvenile Chinook salmon through the mechanisms listed above; however, it is
10800 unknown what total number of these fish are lost to predation. The No Action Alternative is
10801 expected to continue the existing conditions.

10802 Bird predation on juvenile salmon is another factor that determines juvenile salmon surviving
10803 their outmigration. It is estimated that gulls, cormorants, terns, and pelicans consume 11.6
10804 percent of Snake River fall-run Chinook salmon (Evans et al. 2018). Nesting habitat is used as a
10805 measure for predation risk from bird predators. These risks would remain the same under the
10806 No Action Alternative.

10807 During juvenile outmigration, instances of higher turbidity can decrease predation rates because
10808 reduced clarity of water hides juveniles so their susceptibility to predation decreases. The No
10809 Action Alternative is expected to have no changes to timing and duration of higher turbidity.

10810 Approximately 1.5 million Snake River Fall Chinook salmon would be transported under the No
10811 Action Alternative each year (39 percent). Recent studies indicate that there is an advantage to
10812 transporting Snake River Fall Chinook later in the season. Smith et al. (2017) suggested
10813 transporting these fish, beginning on July 1 each year, would maximize returns.

10814 *Adult Migration/Survival*

10815 Adults migrating upstream have been studied for effects of having been barged downstream as
10816 juveniles and were found to have increased straying rates relative to juveniles that completed
10817 in-river migration downstream to the estuary (Bond et al. 2017). The effect can be estimated
10818 from the proportion and timing of juveniles transported downstream from collector projects.
10819 Bond et al. (2017) found that adult fall-run Chinook salmon bound for the Snake River were
10820 more likely to stray into the upper Columbia River if they were barged as juveniles. Under the
10821 No Action Alternative, *Juvenile Fish Transportation in the Columbia and Snake Rivers* measure,
10822 fall-run Chinook transportation would continue at approximately 39 percent of the juvenile
10823 outmigrant population. While this action improves the total number of fish that return, it would
10824 continue the rate of straying to other tributaries and basins.

10825 High water temperatures can cause migrating adult salmon to stop or delay their migration or
10826 can increase fallback after ascending a dam. When they exceed 20°C, water temperatures delay
10827 adult migration during summer/fall. To analyze potential effects, the frequency that water
10828 temperatures in the reach of Lower Granite to Bonneville Dam exceed 20°C August to
10829 September was used as measured at McNary and Ice Harbor Dams. At McNary Dam, 58.3
10830 percent of all days are over 20°C, and at Ice Harbor, 54.3 percent of days are over 20°C. During
10831 August and September under the No Action Alternative, nearly 60 percent of all days at McNary
10832 and Ice Harbor Dams are expected to be over 20°C. Delays in adult migration are expected due
10833 to elevated temperatures during August. The effect becomes reduced downriver in this reach.

10834 During the peak migration period through the dams (August and September), approximately
10835 50.1 percent of all days have a temperature differential greater than 2°C.

10836 In addition to finding appropriate gravel sizes, the depth of water is necessary for successful
10837 deposit of fertilized eggs into the gravel. Fall Chinook salmon vary in the depth of water they
10838 select; the range in the Snake River Basin was found to be from 3 to 26 feet deep (1.0 to 8.1 m;

10839 Geist and Dauble 1995; Dauble et al. 1999). The No Action Alternative would not change
10840 current conditions in the CRS project area.

10841 Other water quality parameters include sediment levels measured in total suspended solids and
10842 DO concentrations. Both parameters are measured in mg/L. The average sediment
10843 concentrations in current conditions are approximately 2 mg/L, and no change is anticipated in
10844 the No Action Alternative. The typical DO concentrations in the Snake River are between 9.5
10845 and 11 mg/L, which poses no adverse effect for fish species. Under the No Action Alternative,
10846 no adverse effects are expected from the oxygen concentrations.

10847 ***Lower Columbia River Salmon and Steelhead***

10848 Lower Columbia River Chinook Salmon

10849 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower
10850 Columbia River Chinook salmon.

10851 *Summary of Key Effects*

10852 Lower Columbia River Chinook salmon are primarily affected by factors outside the scope of the
10853 operations and maintenance of the CRS, but to some extent Lower Columbia River Chinook
10854 salmon could be affected by passage conditions at Bonneville Dam, and to a lesser extent, The
10855 Dalles Dam. Only five of 32 populations in this ESU are affected by passage conditions at
10856 Bonneville Dam and, to a lesser extent, The Dalles Dam: upper Gorge Fall Run, White Salmon
10857 Fall Run, Hood River Fall Run, White Salmon Spring Run, and Hood River Spring Run Chinook
10858 salmon.

10859 Spill and flows affect the migration survival and travel timing of juveniles. Adults are influenced
10860 from operation of the CRS under the No Action Alternative primarily by spill; as the percentage
10861 of spill increases, so does the likelihood of adult Lower Columbia River Chinook being pushed
10862 downstream (i.e., fallback) below Bonneville Dam. Water temperature and TDG are also
10863 considerations for adult and juvenile survival. These are influenced by the following measures
10864 under the No Action Alternative: *Spill Operations, Lower Columbia and Snake River Operations,*
10865 *Water Quality Plan for TDG and Water Temperature, Spill Operations to Improve Juvenile*
10866 *Passage, and the Fish Passage Plan.*

10867 No Action Alternative results for metrics used to compare MOs for Lower Columbia River
10868 Chinook salmon include the following:

- 10869 • Juvenile project survival, Bonneville reservoir and dam (using Snake River spring-
10870 run/summer-run Chinook salmon as a surrogate) estimated at 89.0 percent
- 10871 • Bonneville Dam outflows, April to June
- 10872 • Bonneville Dam outflows, August to September
- 10873 • Spill proportion, Bonneville Dam

- 10874 • Temperature, The Dalles Dam, days exceeding state standard = 71 days
- 10875 • Temperature, Bonneville Dam, days exceeding state standard = 58 days
- 10876 • TDG, The Dalles Dam, days exceeding state standard = 33 days
- 10877 • TDG, Bonneville Dam, days exceeding state standard = 61 days

10878 *Juvenile Migration/Survival*

10879 The change in juvenile survival for the portion of the fish passing Bonneville Dam were assessed
10880 using Snake River spring-run/summer-run Chinook salmon as a surrogate. Interestingly,
10881 Bonneville Dam is the only CRS project where higher spill can result in lower juvenile survival
10882 and vice-versa (personal communication, Zabel). Refer to the Snake River spring/summer-run
10883 Chinook salmon analysis as a surrogate for juvenile migration and survival of lower Columbia
10884 River Chinook salmon.

10885 Some lower Columbia River Chinook salmon juveniles migrate in the spring; their travel time
10886 can be affected by changes in spring (April through July) flows. Other Lower Columbia River
10887 Chinook salmon juveniles emigrate in late summer or early autumn and rely heavily on estuary
10888 habitats before moving on out to the ocean. These juveniles are also subject to effects from
10889 increased TDG to some extent. Under the No Action Alternative, TDG would exceed the state
10890 standard a total of 33 days in The Dalles Dam tailrace and 61 days in the Bonneville Dam
10891 tailrace.

10892 *Adult Migration/Survival*

10893 The area where Lower Columbia River Chinook salmon experience the effects of the CRS the
10894 most is near Bonneville Dam, and to lesser extent, The Dalles Dam. Based on PIT-tag detections
10895 of surrogate species Snake River spring-run/summer-run Chinook salmon, at Bonneville Dam
10896 and later redetected at upstream dams, observed estimates of upstream Chinook salmon
10897 survival rates were 98.6 percent (NMFS 2019). Under the No Action Alternative, adult lower
10898 Columbia River Chinook salmon are expected to have similarly high success rates in upstream
10899 passage at Bonneville Dam.

10900 Adult Lower Columbia River Chinook salmon are vulnerable to predation throughout the lower
10901 Columbia River. This vulnerability is primarily for the nine spring-run populations that migrate
10902 during May and June, when pinniped abundance is highest.

10903 Lower Columbia River Steelhead

10904 Four of the 23 populations in the Lower Columbia River steelhead DPS pass Bonneville Dam:
10905 Wind summer-run steelhead, Hood summer-run steelhead, Hood winter-run steelhead, and
10906 upper Gorge winter-run steelhead.

10907 Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

10908 *Summary of Key Effects*

10909 Observed data estimated a 96.9 percent passage survival for juvenile Lower Columbia River
10910 steelhead at Bonneville Dam and passage at Bonneville Dam would be similar under the No
10911 Action Alternative's *Lower Columbia and Snake River Operations, Spill Operations to Improve*
10912 *Juvenile Fish Passage, and Fish Passage Plan* measures.

10913 No Action Alternative results for metrics used to compare MOs for lower Columbia River
10914 steelhead include the following:

- 10915 • Juvenile project survival, Bonneville Reservoir and Dam (see Snake River steelhead as a
10916 surrogate) = 87.3 percent
- 10917 • Bonneville Dam outflows, March to June (juvenile outmigration)
- 10918 • Bonneville Dam outflows, adult migration time period year-round
- 10919 • Spill proportion, Bonneville Dam
- 10920 • Temperature, The Dalles Dam, days exceeding state standard = 71 days
- 10921 • Temperature, Bonneville Dam, days exceeding state standard = 58 days
- 10922 • TDG, The Dalles Dam, days exceeding state standard = 33 days
- 10923 • TDG, Bonneville Dam, days exceeding state standard = 61 days

10924 *Juvenile Migration/Survival*

10925 Ploskey et al. (2012) found actual survival of juvenile steelhead through Bonneville Dam to be
10926 96.9 percent. These results were based on a study that looked at survival through the spillway,
10927 Powerhouse 2 and Powerhouse 1. Snake River steelhead was used as a surrogate to provide an
10928 estimate of juvenile passage survival through Bonneville Dam for those populations located
10929 upstream of Bonneville Dam. Under the No Action Alternative, juvenile survival through
10930 Bonneville Reservoir and Dam would be 87.3 percent. Based on observed data (Ploskey et al.
10931 2012) and modeled surrogate species information, juvenile survival through Bonneville Dam
10932 would be 87 to 97 percent. Refer to Snake River steelhead analysis as a surrogate for lower
10933 Columbia River steelhead for additional juvenile migration and survival information.

10934 For all Lower Columbia steelhead, including those populations that do not pass Bonneville Dam,
10935 reduced flows April through June from CRS operation would increase travel times and reduce
10936 access to high-quality estuarine habitats (NMFS 2019). In addition, exposure to increased
10937 temperatures and elevated TDG during outmigration would further influence juvenile survival.

10938 Researchers have not estimated predation rates for Lower Columbia River steelhead because
10939 these fish are not PIT-tagged.

10940 *Adult Migration/Survival*

10941 The area where Lower Columbia River steelhead experience the effects of the existence and
10942 operation of the CRS is predominantly near Bonneville Dam, and to lesser extent, The Dalles
10943 Dam. The most recent estimates of upstream survival (Rayamajhi et al. 2012) indicate Lower
10944 Columbia River steelhead survival of adults passing upstream of Bonneville Dam is 98.5 percent.

10945 Summer-run steelhead migrate upstream from May to October, and winter-run steelhead
10946 migrate December to May, so changes in flows, spill, temperature, or TDG could affect adult
10947 migration and survival. Additionally, kelts moving downstream post-spawning could also be
10948 affected during and soon after these times. Migration of kelts occurs from March through July
10949 (Keefer et. al, 2016). Kelt migration can be affected by the extreme energetic demands of
10950 spawning and iteroparity, harvest, and the Columbia River System (Coletelo et al. 2014). Refer
10951 to Middle Columbia River Steelhead in Section 3.5.3.2 for additional information on kelts and
10952 system passage.

10953 Adult Lower Columbia River steelhead are vulnerable to pinniped predation throughout the
10954 lower Columbia River. This vulnerability is primarily for spring-run adult populations that
10955 migrate during May and June, when pinniped abundance is highest.

10956 Lower Columbia River Coho Salmon

10957 The ESA-listed Lower Columbia River coho salmon ESU includes three geographical groupings
10958 (or strata): Coast, Cascade, and Gorge. Only Gorge coho salmon travel upstream far enough to
10959 pass Bonneville Dam.

10960 See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower
10961 Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult
10962 Lower Columbia River coho salmon.

10963 *Summary of Key Effects*

10964 Survival rates of Lower Columbia River coho salmon transiting through the Bonneville pool and
10965 Bonneville Dam are expected to remain similar or increase somewhat under the No Action
10966 Alternative, due to the installation of the Bonneville Corner Collector and the *Lower Columbia
10967 and Snake River Operations, Spill Operations to Improve Juvenile Fish Passage, and Fish Passage
10968 Plan* measures. Modeled data includes historical records of fish passage before the Bonneville
10969 Corner Collector as constructed.

10970 *Juvenile Migration/Survival*

10971 Passage through the Bonneville Reservoir and Dam would continue to affect the survival of
10972 Lower Columbia River juvenile coho salmon under the No Action Alternative. Juvenile coho
10973 salmon outmigration timing generally overlaps with that of Snake River spring-run/summer-run
10974 Chinook salmon, and the size of these juvenile species are closely aligned; therefore, the Snake
10975 River spring-run/summer-run Chinook salmon were used as a surrogate for the Lower Columbia

10976 River juvenile coho salmon. Juvenile Snake River spring-run/summer-run Chinook salmon are
10977 estimated to have a 95 to 96 percent survival rate at Bonneville Dam (Ploskey et al. 2012). Coho
10978 salmon smolts from tributaries in the Bonneville Reservoir are likely to have similar survival
10979 rates passing downstream through Bonneville Dam (NMFS 2019).

10980 Refer to the Snake River Spring/Summer Chinook Salmon section (Section 3.5.2.2), No Action
10981 Alternative, for additional information on juvenile survival rate estimates under the No Action
10982 Alternative.

10983 *Adult Migration/Survival*

10984 Lower Columbia River adult coho salmon are assumed to have passage success rates similar to
10985 that of all coho salmon (including reintroduced upper river species) passing Bonneville Dam.
10986 Because there are no adult coho salmon-specific passage survival models available, it was
10987 necessary to rely on historic survival rates for a surrogate species to estimate and compare
10988 adult coho salmon passage rates under the No Action Alternative.

10989 The timing of adult coho salmon upstream migration generally overlaps with that of Snake River
10990 fall-run Chinook salmon; although the fall-run Chinook salmon migration tends to start earlier in
10991 some years. For these reasons, Snake River fall-run Chinook salmon were used as a surrogate
10992 for Lower Columbia River coho salmon.

10993 Based on Snake River fall-run Chinook adult PIT-tag detections at Bonneville Dam between 2013
10994 and 2017, the average survival rate for Lower Columbia River adult coho salmon passing
10995 upstream of the dam is 97.6 percent (94.5 to 100 percent; 2019 CRS BiOp). This applies only to
10996 populations that migrate to natal streams within the Bonneville pool. Under the No Action
10997 Alternative, Lower Columbia River adult coho salmon survival rates are expected to continue in
10998 this range.

10999 Columbia River Chum Salmon

11000 One population in this ESU would be affected by operations at Bonneville Dam: Upper Gorge
11001 chum salmon.

11002 Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia
11003 River chum salmon.

11004 *Summary of Key Effects*

11005 Chum salmon rarely pass Bonneville Dam. For the period between 2008 and 2017, on average,
11006 96 adults passed this dam each year. Chum spawning and incubation habitat is maintained
11007 through operations at Grand Coulee, which results in sufficient water passing through
11008 Bonneville Dam in 90 percent of years. Chum operations would continue at current levels under
11009 the No Action Alternative's *Chum Spawning Flow* measure.

11010 *Larval Development/Juvenile Rearing*

11011 Maintaining water saturation of 105 percent TDG or less from November 1 to April 30 appears
11012 to provide a sufficient level of protection to chum salmon eggs and sac fry incubating in the
11013 gravel downstream of Bonneville Dam. Under measures in the No Action Alternative, including
11014 *Spill Operations, Water Quality Plan for TDG and Water Temperature, and Spill Operations to*
11015 *Improve Juvenile Fish Passage*, chum sac fry would be exposed to TDG above 105 percent in 5
11016 out of 80 years. Those exceedances all would occur in the mid- to late April timeframe when
11017 most of the chum have emerged from the gravel.

11018 *Juvenile Migration/Survival*

11019 There are no studies of downstream passage survival for juvenile Columbia River chum salmon.
11020 The survival of downstream migrants is likely to have improved in recent years and would be
11021 expected to continue under the No Action Alternative due to the construction of the Bonneville
11022 Corner Collector.

11023 There is no direct estimate of Bonneville Dam and Reservoir passage specific to juvenile chum
11024 salmon, so juvenile Snake River spring-run/summer-run Chinook salmon were used as a
11025 surrogate to estimate effects to chum salmon. Juvenile Snake River spring-run/summer-run
11026 Chinook salmon are estimated to have a 95 to 96 percent survival rate at Bonneville Dam
11027 (Ploskey et al. 2012). 2012 Chum salmon smolts from tributaries in the Bonneville Reservoir are
11028 likely to have similar survival rates passing downstream through Bonneville Dam (NMFS 2019).
11029 Refer to Snake River spring/summer-run Chinook salmon analysis for additional surrogate
11030 information for Columbia River chum salmon. Grand Coulee is operated to balance the needs of
11031 multiple salmon species. The operations provide chum flows downstream of Bonneville Dam,
11032 along with Vernita Bar operations for fall-run Chinook salmon, and spring flow augmentation
11033 from the start of chum spawning in November through the end of chum emergence
11034 (approximately the end of April). The chum operation is intended to maintain sufficient water
11035 depth to protect chum spawning and incubation habitat at the Ives Island complex below
11036 Bonneville Dam. The Bonneville Dam tailwater elevation (measured at the Tanner Creek gage)
11037 affects chum access to the Ives/Pierce Islands spawning area. Tailwater elevations below 11.3
11038 feet create connectivity issues to spawning channels and poorer conditions in the lower
11039 spawning elevation habitat. As tailwater elevations increase above 13.5 feet, some habitat in
11040 the lower elevations becomes unsuitable for chum due to higher water velocities. In addition,
11041 eggs spawned at higher elevations would be at higher risk of being dewatered later in the year
11042 if there is an insufficient water supply. Under the No Action Alternative, Bonneville Dam flows
11043 would be managed to prevent chum spawning at those higher elevations that are at greater risk
11044 of dewatering. How operations affect the ability of Grand Coulee to provide winter flows to
11045 protect chum redds and provide sufficient access to habitat was calculated using hydrology
11046 modeling. Under the No Action Alternative, chum flows would be met in 90 percent of years.

11047 *Adult Migration/Survival*

11048 Adult chum salmon counts at the ladders at Bonneville Dam have ranged from 17 in 2000 to
11049 411 in 2003, averaging 107 adults passing Bonneville Dam per year. The most recent 10-year
11050 average (2008 to 2017) is 96 adults (McCann 2018), which is similar to the 107 adults
11051 mentioned above as the average number of adults moving upstream of Bonneville Dam
11052 between 2013 and 2017 based on dam counts. NMFS (2008a) estimated that the adult passage
11053 mortality rate for chum salmon at Bonneville Dam was similar to that of Snake River spring-
11054 run/summer-run Chinook salmon, which are present during the same time period (about 3.1
11055 percent). Passage survival estimates incorporate passage under general operations and typical
11056 maintenance (e.g., screen blockages/cleaning) conditions, and previous survival estimates are
11057 anticipated to continue under the No Action Alternative.

11058 Adult chum salmon are near the Bonneville Dam tailrace November to December each year,
11059 and therefore are not likely to be exposed to elevated levels of TDG. Eggs are present in the
11060 mainstem spawning area near the tailrace (the Ives/Pierce Island area) during winter, and fry
11061 are present in the bypass system at Bonneville Dam and the mainstem spawning area through
11062 May. The risk of GBT to these life stages is minimized by maintaining a Bonneville tailwater
11063 elevation of between 11.5 and 13 feet through spawning if reservoir elevations (indicative of
11064 available storage) and climate forecasts indicate this operation would be feasible (NMFS 2019).
11065 GBT risk is anticipated to remain at current levels under the No Action Alternative.

11066 Pinniped predation on chum salmon is expected to increase based upon increasing numbers of
11067 pinnipeds. However, the magnitude of pinniped predation on chum salmon is likely lower than
11068 on spring-run Chinook salmon, due to fewer pinnipeds being present when chum salmon
11069 migrate.

11070 **Other Anadromous Fish**

11071 *Pacific Eulachon*

11072 Summary of Key Effects

11073 The time between the peak spawning runs, egg development, and larval emergence timed with
11074 the spring freshet to adequately disperse larvae to adequate food sources would continue to be
11075 highly variable, with an average of 168 days between spawning temperature triggers and peak
11076 flows (158 days in high-flow years, and 156 days in low-flow years). Freshwater flow rates can
11077 affect larval survival if reduced flow rates result in a mismatch of larvae and their planktonic
11078 food supply. Relatively low freshwater inputs into the nearshore environment would continue
11079 to moderately limit plankton food supply for larval eulachon in the April to July period. A
11080 hydrology analysis showed none of the MOs would appreciably affect the estuary/plume
11081 environment.

11082 Bird predation risk can be influenced by flow rates. Higher flows are linked to higher predation
11083 rates on eulachon, whereas at lower flows, birds tend to switch to marine prey. Operation of

11084 the CRS system under the No Action Alternative would continue to result in lower peak
11085 turbidity levels in spring, but the relationship between turbidity and eulachon is not clear.
11086 Eulachon would continue to migrate into the Columbia River from November to March, with
11087 specific dates of migration and spawning based on a variety of environmental factors, including
11088 temperature, high tides, and ocean conditions (NMFS 2017). Modeled data for the No Action
11089 Alternative (based on the period of record for Bonneville tailwater temperatures) indicate that
11090 temperatures would typically be favorable for triggering upstream migration by mid to late
11091 November, with the spawning trigger (4°C) occurring in late December/early January of each
11092 run year. The location of spawning would continue to be dependent on the size of the run, as
11093 well as other environmental factors. Runs are expected occasionally as far up the Columbia
11094 River as Bonneville Dam. Bonneville Dam is near the upstream range of spawning, but it could
11095 continue to impede access further upstream in years of very large eulachon runs. Possible
11096 eulachon injury or mortality could continue if any eulachon pass through Bonneville Dam.
11097 Because Bonneville Dam is the near the upstream range of spawning, this would be a very
11098 minor impact. Tributary access to major spawning tributaries would remain unimpeded.
11099 Eulachon need pea-sized gravel and coarse sand for spawning. Substrate can be affected by
11100 flows, particularly during changes in peak flows. A portion of eulachon would continue
11101 mainstem spawning where appropriate substrate exists, and tributary spawning substrate
11102 would not be affected.

11103 ***Green Sturgeon***

11104 Summary of Key Effects

11105 Columbia River use by green sturgeon is limited to foraging habitat for adults. Key effects of the
11106 No Action Alternative are focused on how flows and temperatures influence the cues for
11107 entering the Columbia River as well as the availability and distribution of food sources.

11108 Columbia River water temperatures (relative to ocean temperatures) cue the spring arrival and
11109 fall departure of green sturgeon. The date that water temperatures first reach 15°C in spring
11110 and the date that they drop below 15°C in the fall can be used as an indicator for arrival and
11111 departure in the estuary (Moser and Lindley 2007). Currently, green sturgeon arrive in June and
11112 leave in September or October. In some years, the arrival date can be as early as May and the
11113 departure date as late as December. Flows and water temperatures anticipated under the No
11114 Action Alternative are anticipated to result in green sturgeon migrating within a similar date
11115 range and are expected to continue supporting adequate rearing conditions.

11116 Changes in Columbia River outflow can change the location of the saltwater/freshwater
11117 interface that is important for green sturgeon feeding. Under the No Action Alternative, the
11118 lower Columbia River would continue to provide good foraging habitat for green sturgeon.

11119 ***Pacific Lamprey***

11120 Ongoing Existing Mitigation Programs

11121 There are numerous actions to benefit Pacific lamprey, including projects like the Pacific
11122 Lamprey Conservation Initiative and the Tribal Pacific Lamprey Restoration Plan. These plans
11123 improve understanding of Pacific Lamprey status and limiting factors, implement high-priority
11124 habitat restoration actions, increase populations through reintroduction and translocation
11125 efforts, and conduct artificial propagation research with plans to release hatchery juveniles in
11126 select areas pending an environmental assessment.

11127 Summary of Key Effects

11128 Unlike salmon and steelhead, larval lamprey spend several years rearing in the freshwater
11129 environment of the Columbia and Snake Rivers and tributaries. Factors important for lamprey
11130 relative to Columbia River System Operations include how they affect dam passage, flow and
11131 reservoir levels, water quality, predation, and habitat conditions. Key effects of the No Action
11132 Alternative on lamprey include continued effects to upstream migration of adults and
11133 downstream migration of juveniles in the form of passage delays, direct individual mortalities,
11134 and physical stress. The No Action Alternative also would continue effects on larval rearing via
11135 reservoir drawdowns and project maintenance dredging. Not enough years of dam passage
11136 efficiency data are available to determine whether recent passage improvements have had
11137 effects at the population scale and if the improvements would continue under the No Action
11138 Alternative.

11139 Larval Development/Juvenile Rearing

11140 System operations affect juvenile rearing in shallow waters when water elevation fluctuations
11141 dewater larvae that reside in soft substrates in the shoreline. Flow reduction rates that drop the
11142 amount of shoreline covered by water (shoreline inundation) at less than 4 inches per hour
11143 occur naturally; however, dam operations can cause a faster rate of water receding from the
11144 shore. Under the No Action Alternative, the effects of these more rapid fluctuations include
11145 changes to distribution of rearing habitat, direct mortality, and increased predation exposure⁴.

⁴ The evidence for these effects comes from a series of preliminary studies:

- Jolley et al. (2014, 2016) conducted surveys in mainstem areas of Columbia and lower Snake Rivers to determine presence/absence of rearing larvae potentially vulnerable to dewatering. Lamprey larvae were found at various depths in the mainstem Columbia and Snake Rivers and were commonly found near tributary deltas, in areas vulnerable to changes (seasonal or otherwise) in surface elevation.
- Mueller et al. (2015) used existing bathymetry and operations information to model relative risk of dewatering.
- Liedtke et al. (2015) conducted laboratory experiments with larvae, simulating dewatering events and monitoring lamprey response to dewatering of their habitat.

11146 Juvenile Migration/Survival

11147 Water temperatures and physical structures affect juvenile lamprey during their outmigration.
11148 Juvenile outmigration typically occurs in late fall through the spring into early summer. High-
11149 flow freshet events typically trigger outmigration events. The evidence of this is the timing of
11150 when juvenile fish are found in the tributary screw traps; this timing occurs with freshet events
11151 in winter and aligns with annual summary hydrographs (Mesa et al. 2015). However, warmer
11152 temperatures affect juvenile outmigration as well, and they are compelled to move out of the
11153 higher elevations of the system faster in warmer water temperatures due to physiological
11154 stress. Temperature data modeled from three of the Lower Snake River Dams show the number
11155 of days the water temperature exceeds state standards, which is expected to continue in the
11156 No Action Alternative:

- 11157 • Lower Granite Dam: 4.4 days
- 11158 • Little Goose Dam: 37.0 days
- 11159 • Lower Monumental Dam: 47.2 days

11160 Juvenile lamprey pass the CRS projects through all downstream passage routes and can
11161 potentially be harmed in any of the project components. Relative distribution across passage
11162 routes is not well understood, so the magnitude of all the injury and mortality effects on
11163 juvenile lamprey is unknown. As juveniles migrate downstream from their rearing areas, they
11164 must pass as many as eight projects of the Lower Snake and Columbia Rivers.

11165 The majority of juvenile lamprey swim low in the water column below the depth of screens and
11166 pass the CRS projects via turbines. Fyke net evaluations of run-of-river fish at John Day Dam,
11167 McNary Dam, Bonneville Dam, and other dams found the majority (more than 70 percent) of
11168 juvenile lamprey appeared to move downstream low in the water column, below the turbine
11169 intake bypass screens installed for salmonids (BioAnalysts Inc. 2000; Moursund et al. 2003;
11170 Monk et al. 2004). Results of these fyke net studies provide an estimate of relative use of
11171 turbines at approximately 70 percent versus juvenile bypass systems at about 30 percent.

11172 Lampreys that survive these passage routes can become injured or disoriented, putting them at
11173 greater risk of predation. Direct observations of predation on juvenile lamprey in powerhouse
11174 tailraces suggest passage via this route is substantial.

11175 Turbine cooling water strainers can entrain juvenile lampreys in the turbine scroll case located
11176 upstream of turbines, which results in mortality. The evidence of this harmful mechanism is
11177 through mortality counts from routine cooling water strainer inspections at CRS projects. The
11178 Corps has developed a design for exclusion of juvenile lamprey and other fish from cooling
11179 water strainer intakes. The design would be tested at Ice Harbor as turbines are replaced with
11180 Improved Fish Passage turbines (IFPs) (under the No Action Alternative's *Ice Harbor Projects*
11181 *Turbines 1 to 3 Replacement and Generator Rewind* measure).

11182 Juveniles that do not directly enter the turbines can be harmed and killed by impingement
11183 (being pushed up against the screens); this occurs mostly in the extended length submersible
11184 bar screens at McNary, Little Goose, and Lower Granite Dams. The Corps has observed the
11185 direct mortality of juveniles and a high number of entangled fish (Moursund et al. 2001, 2003).
11186 Bar screen installations at McNary Dam have been delayed until mid-April each year since 2009
11187 to reduce this effect based on timing of lamprey migration. At other locations, lamprey timing is
11188 concurrent so bar-screen installation for the protection of salmon is not delayed. Woven mesh
11189 screen reduces impingements, but this has not been installed due to cost. Note that some dams
11190 and powerhouses have no turbine intake bypass screens and that other dams have what
11191 appear to be relatively benign Submersed Traveling Screens that use woven mesh.

11192 Juvenile lamprey that migrate higher in the water column can pass via spillways, which may
11193 cause injury or indirect effects. It is unknown what proportion of lamprey use this route, and
11194 therefore the magnitude of effects to the population is unknown. The evidence for use of this
11195 passage route is direct observation of tailrace predation by gulls; lamprey become disoriented
11196 at spillways and become more susceptible to predation (Zorich et al. 2010, 2011, 2012).

11197 Routine maintenance dredging occurs every 3 to 5 years for navigation in the lower Snake River
11198 in a channel 14 feet deep and 250 feet wide associated with the four lower Snake River Dams.
11199 The Corps also periodically dredges at Bonneville forebay locations, including immediately
11200 upstream of Bradford Island Fish Ladder exit, and upstream of Washington-shore fish turbine
11201 units. Dredging is necessary to remove debris and ensure that fish passage facilities are
11202 operating as designed. Juvenile lampreys are susceptible to entrainment in dredging
11203 equipment, but the number of fish harmed or killed is unknown. Juvenile lamprey have highest
11204 densities in fine particle, high organic matter substrates rather than the coarse mineral sand
11205 found in the channel. Sampling during dredging at Bonneville reservoir found no lamprey
11206 present. Although juvenile lamprey may be present in areas targeted for dredging, densities are
11207 thought to be site specific and most likely seasonal. Direct effects of the dredging action on
11208 juvenile lamprey is not well understood. Under the No Action Alternative, navigation channel
11209 maintenance would continue to occur periodically. Maintenance dredging at Bonneville would
11210 be expected to continue as needed.

11211 Adult Migration/Survival

11212 Dams inhibit upstream migration of adult lamprey to spawning areas, causing direct mortality
11213 or physical stress. Each dam that must be ascended poses risk of mortality or contributes to
11214 stress that reduces fitness for spawning. There is a poor understanding of magnitude of the
11215 impact to populations.

11216 Only a portion of lampreys that attempt to move upstream in the Columbia River can pass the
11217 dams and move into desired spawning areas. Dams create barriers despite having fish ladders,
11218 which were designed for adult salmon. Dams can cause direct mortality or physical stress
11219 among adult lamprey that use conventional fishways. The ladders (designed for salmon) have
11220 too high of velocities, difficult shapes of ladder steps, and right-angled corners that cause
11221 difficulty for ascending lamprey. Lamprey adult upstream passage has been low at Columbia

11222 River dams (Bonneville, John Day, and The Dalles Dams) with 65 percent or lower passage
11223 efficiency (Moser et al. 2002a, 2002b; Keefer et al. 2012). McNary Dam adult passage
11224 efficiencies have ranged from 65 to 75 percent (Keefer et al. 2013). Upstream passage
11225 efficiency at Snake River dams has been higher than at Lower Columbia River dams (Stevens et
11226 al. 2016); recent fish passage improvements at Snake River dams have increased adult passage
11227 survival from 70 to 75 percent (Stevens et al. 2016).

11228 Mainstem dams can cause direct mortality or physical stress among adult lamprey that use
11229 lamprey passage structures or are otherwise diverted into collection structures or traps. Corps
11230 biologists and Corps-funded researchers periodically find dead lamprey in lamprey passage
11231 structures or in holding tanks. Other than equipment failures, mortality causes are often
11232 unknown. High temperatures or other water quality issues may cause physical stress or
11233 mortality of individuals, particularly as lamprey are kept in holding tanks during extended
11234 periods of high temperatures. Other unknown factors are causing lamprey to turn around and
11235 descend the ladders when they are expected to be migrating upstream.

11236 Dam passage efficiency is the number of tagged lampreys that passed a dam divided by the
11237 number of lampreys that approached a fishway. Median dam passage efficiencies across all
11238 study years (1997 to 2010) ranged from 44 percent at Bonneville Dam, up to 68 percent at The
11239 Dalles Dam (Keefer et al. 2012). A study in 2014 found dam passage efficiency was at 49 to 52
11240 percent at Bonneville Dam, 47 percent at The Dalles Dam, 83 percent at John Day Dam, and 100
11241 percent at McNary Dam (Clabough et al. 2015). The Lower Snake River Dams have similar dam
11242 passage efficiencies at 41 to 68 percent (Stevens et al. 2016).

11243 What these low success rates for ladder ascension mean is that attrition through the system
11244 leads to fewer and fewer lampreys that are able to make it further upstream into the system
11245 and reduces access to desired spawning locations. Reduced distribution and abundance reduces
11246 the effect of pheromone attraction cues, which would occur when adults detect the
11247 pheromone outputs of rearing juveniles. After many years of this reduced recruitment of
11248 lamprey to their desired spawning reaches in the watershed, the system has seen degraded
11249 ecosystem and food web effects because lampreys transfer nutrients upstream, so fewer
11250 lampreys mean fewer nutrients.

11251 Under the No Action Alternative, there would be a neutral to decreasing trend in mortality and
11252 an increase in passage efficiency over time as the Corps continues to investigate and address
11253 known lamprey passage impediments. Adult lamprey passage metrics are expected to remain
11254 consistent in the near future and improve incrementally as conventional fishway structures and
11255 operations are modified and lamprey passage structures are installed.

11256 The relationships of other parameters, such as outflows, spill rates, and water temperatures,
11257 with lamprey migration and survival are not well understood. Outflows and water temperatures
11258 are monitored at all of the CRS projects. Lampreys generally migrate faster later in the summer
11259 through most reaches, coinciding with increasing river temperatures and decreasing river
11260 discharge (Keefer et al. 2012). Temperatures greater than 72°F cause stress to adult lamprey
11261 and can reduce migration success, although this is a rare occurrence at Bonneville. High flows

11262 and lower water temperatures correlate to poorer passage success and slower migration speed,
11263 but little is known about the migration cues used by adult lamprey and how these and
11264 migration timing interact. Keefer et al. (2012) speculated that higher flows associated with
11265 higher tailwater elevations at Bonneville might compromise attraction to fishway entrances,
11266 collection channels, and transition pools of ladders. These factors can affect distribution of
11267 lamprey throughout the basin. Lamprey appear to have a relatively flexible migration strategy,
11268 and in some conditions, can overwinter up to 2 years before spawning, although temperature
11269 conditions in the project facilities are unlikely to support this strategy. Effects of different
11270 mainstem flow and temperature conditions on spawning success remain unclear. Total attrition
11271 due to all these factors affects the whole population. All these parameters and effects are
11272 expected to remain constant under the No Action Alternative.

11273 Other stressors, such as predation and contaminants, are known to affect lampreys. Predation
11274 on adults by sea lions at Bonneville Dam is well documented (Corps Annual Reports) and by
11275 white sturgeon is likely to occur. This predation risk can be exacerbated by the delay in adult
11276 migrations at the dams and interactions of the predators and prey within the project structures.
11277 Birds and mammals may also take the opportunity to capture lamprey in structures. All life
11278 stages of Pacific lamprey can be affected by contaminants (CRITFC 2011). Contaminants such as
11279 methyl mercury are bioaccumulated in larval lamprey and can have ecosystem effects on
11280 predators that prey on them (Bettaso and Goodman 2008). These effects would continue under
11281 the No Action Alternative.

11282 ***American Shad***

11283 Summary of Key Effects

11284 Shad are generalists that tolerate a wide range of conditions and thrive in reservoir habitats;
11285 populations are increasing in trend and distribution. Changes in project operations are not likely
11286 to influence their populations, but their distribution and migrations could be affected by
11287 changes in flow, temperatures, or food supply. Both adults and juveniles would continue to
11288 thrive with the abundance of reservoir conditions in the Snake and Columbia Rivers that tend to
11289 favor them over other native fish. They consume up to 30 percent of the zooplankton present
11290 in the rivers and are expected to continue to eat at least that same amount under the No
11291 Action Alternative. Upstream migrating adults would continue to crowd fish ladders in the basin
11292 but also provide a recreational fishing opportunity.

11293 Juvenile Migration/Survival

11294 Juvenile shad thrive in aquatic vegetation found in off-channel habitats provided by reservoir
11295 shorelines (Petersen et al. 2003; Gadomski and Barfoot 1998), and they feed on zooplankton
11296 from June to September. Under the No Action Alternative, the reservoirs associated with the
11297 CRS would continue to provide vegetated shoreline habitat and adequate zooplankton at the
11298 levels that support a robust juvenile shad population. Juvenile shad would continue to
11299 experience high survival in these conditions.

11300 Adult Migration/Survival

11301 Adult shad return to the Columbia River system to spawn when temperatures reach about
11302 16°C, which would occur between June and August under the No Action Alternative. Though
11303 they migrate upstream successfully in all conditions, Hinrichsen et al. (2013) found shad
11304 migrate further upstream under lower dam discharges. Under the No Action Alternative, shad
11305 would continue to thrive and potentially crowd fish ladders that could interfere with salmon
11306 and steelhead migrations.

11307 **RESIDENT FISH**

11308 Resident fish were analyzed as fish communities generally at the scale at which they are
11309 managed and as related to CRS Projects. These communities in Region A include Hungry
11310 Horse/Flathead/Clark Fork (Hungry Horse Dam); Lake Pend Oreille (Albeni Falls Dam) and Pend
11311 Oreille River; and the Kootenai River, including Lake Kooconusa (Libby Dam).

11312 **Region A**

11313 Ongoing Existing Mitigation Programs

11314 There are numerous ongoing actions to benefit resident fish. CKST and MFWP's Hungry Horse
11315 Mitigation projects address habitat loss in the Flathead basin from construction and operation
11316 of Hungry Horse Dam, and the inundation of 72 miles (125.8 km) of the South Fork Flathead
11317 River and its tributaries. Project work assesses population level effects of dam operations on
11318 native fishes, implements habitat improvement, habitat conservation, and fish passage actions,
11319 and quantifies and reduces the effects of non-native aquatic species on native fishes.

11320 Part of the mitigation work for Hungry Horse Dam involves fish production at two small
11321 hatcheries in northern Montana. Bonneville funds Creston National Hatchery's production of
11322 200,000 juvenile westslope cutthroat trout and 200,000 juvenile rainbow trout for stocking in
11323 Montana waters. Stocking occurs according to the fisheries management strategy of MFWP and
11324 CSKT. Bonneville also funded the construction of Sekokini Springs Isolation Facility for
11325 spawning, rearing, isolation, and release of genetically unique westslope cutthroat trout stocks
11326 originating from wild parent stocks.

11327 Mitigation actions for the fish impacts of Libby Dam are coordinated with adjacent tribal, state,
11328 and provincial governments. Programs like the Libby Dam Fisheries Mitigation and
11329 Implementation Plan (Montana Fish Wildlife and Parks et al. 1998) seek to enhance fish stocks
11330 affected by the Columbia River System in the Montana portion of the Kootenai Watershed
11331 consistent with white sturgeon, bull trout, westslope cutthroat trout and redband trout
11332 conservation needs and requirements. This program implements and evaluates habitat
11333 enhancement to alleviate limiting factors to native species including projects to protect or
11334 enhance spawning, rearing, and over-wintering habitats. Additionally, since 2010, Bonneville
11335 has funded the Kootenai Tribe of Idaho (KTOI) to manage and implement habitat restoration
11336 measures within the Kootenai River downstream of Libby Dam. These habitat restoration

11337 actions have increased active floodplain, increased river pool depths, reduced erosion, and
11338 provided increased complexity and velocities to aid in the survival and potential reproduction of
11339 Kootenai River white sturgeon and potential benefit for the native salmonid populations as
11340 well. Bonneville also funds IDFG for ongoing burbot monitoring actions, including evaluating
11341 population demographics, spawning activity and natural recruitment, and other actions. In
11342 addition to their habitat work, KTOI operates the Kootenai Tribal sturgeon hatchery and the
11343 Tribal Twin Rivers sturgeon and burbot hatchery facility, which was constructed in 2014. These
11344 facilities have preserved sturgeon genetic and demographic diversity and have pioneered
11345 culture techniques for burbot.

11346 Bonneville's F&W Program also provides funding to the Kalispel Tribe to develop and
11347 implement a resident fish mitigation program for the impacts from Albeni Falls Dam. This work
11348 includes improving bull trout habitat within the basin. Additional priorities are to restore
11349 habitats for westslope cutthroat trout and maintain the suppression effort on non-native
11350 predator and competitive fish species within the Pend Oreille Basin. Finally, through the 2018
11351 Northern Idaho Wildlife Agreement, Bonneville and the State of Idaho work to protect and
11352 enhance 1,378 acres to fully address operational impacts of Albeni Falls Dam on wildlife. Much
11353 of this work will focus on the Clark Fork Delta and restoration of riparian habitat and the
11354 reestablishment of wetland plant communities, which will also benefit resident fish species.

11355 ***Kootenai River Basin***

11356 Summary of Key Effects

11357 Currently, water releases from Libby Dam can have detrimental effects to fish species in the
11358 Kootenai River downstream of Libby Dam related to altered flow and temperature. Under the
11359 No Action Alternative, spring flows would continue to increase at a rate less than normalized
11360 rates. The diminished spring flows would continue to reduce aquatic food sources associated
11361 with inundated river habitats between Libby Dam and Kootenay Lake in British Columbia.
11362 Burbot populations would be expected to continue to grow in abundance with continuation of
11363 the burbot restoration efforts.

11364 Under the No Action Alternative, fluctuations in discharge from Libby Dam in the winter would
11365 continue to adversely affect benthic organisms. Cottonwood seedlings would continue to have
11366 variable survival depending on timing, stage, and duration of spring flows, along with the winter
11367 stage during the ensuing winter. In addition, the discharge regime from Libby Dam would
11368 continue to not provide for successful burbot recruitment, and spring water temperatures
11369 would be too cold to allow for proper larval development.

11370 Habitat Effects Common to This Fish Community

11371 Important operational relationships affecting species in this basin are related to river flows due
11372 to the construction and operation of Libby Dam. Prolonged periods of reduced early spring flow
11373 from the dam has changed the river ecosystem from mid-March through mid-May. During this
11374 period, it is critical for river flow and stage to rise and inundate riparian and side channel

11375 habitat to promote productivity. Under the No Action Alternative, the rate of increase in spring
11376 flows would be about one-third of a more normalized hydrograph needed to establish
11377 productivity.

11378 Bull Trout

11379 Important operational relationships affecting bull trout habitat in this basin include reservoir
11380 elevations in Lake Koochanusa and the impact of these elevations on reservoir productivity, how
11381 reservoir temperatures influence discharge temperatures, and how discharges from Libby Dam
11382 affect downstream habitat inundation. Higher reservoir elevations in the warm summer months
11383 results in a thicker water layer in which primary production and zooplankton production (i.e.,
11384 euphotic zone) occurs in Lake Koochanusa. High reservoir elevations during winter (which have a
11385 large quantity of cold water) reduce the ability to provide warm/normative discharge
11386 temperature during spring and early summer in the Kootenai River. Bull trout forage in the
11387 reservoir and rely on this production in the river for food the following winter. Lake productivity
11388 under the No Action Alternative would continue to beneficially affect bull trout (both ESA-listed
11389 in the U.S. and non-listed individuals in Canada) growth and/or survival in Lake Koochanusa
11390 (Marotz et al. 1996; Marotz et al. 1999). However, lower flows and colder temperatures in
11391 spring and summer would likely suppress primary and secondary production in the river
11392 downstream of Libby Dam.

11393 The minimum elevation of Lake Koochanusa each year influences insect larvae production the
11394 following year. The minimum elevation of the reservoir is typically in mid-April. The higher this
11395 minimum elevation is each year, the greater the insect larvae production and the more food
11396 available for juvenile bull trout (Marotz et al. 1996; Marotz et al. 1999; Chisholm et al. 1989).
11397 Under the No Action Alternative, the minimum reservoir elevation would be 2,366 feet during
11398 median years.

11399 The maximum elevation of Lake Koochanusa is related to volume and surface area and to the
11400 proximity of the reservoir surface to terrestrial insect deposition, a food source for bull trout.
11401 The reservoir typically reaches maximum elevation in early August (Marotz et al. 1996;
11402 Sylvester et al. 2019). Under the No Action Alternative, the median maximum reservoir
11403 elevation would be 2453.1 feet, which is 5.9 feet below full pool.

11404 Water temperature in Lake Koochanusa influences bull trout habitat suitability in the reservoir.
11405 Reservoir surface elevation and volume also influence the thermal structure of the pool.
11406 Reservoir temperature (Dunnigan, unpublished) is determined by several variables, the most
11407 indicative of which are volume of the reservoir through the winter (as measured by minimum
11408 pool elevation in April), inflow, and air temperature. Fish seek preferred temperatures, and the
11409 volume and temperature ranges influence the amount of preferred habitat. For bull trout,
11410 optimal growth occurs at 13.2°C, while the upper lethal temperature for bull trout is 20.9°C
11411 (Selong et al. 2001). Under the No Action Alternative, the mean monthly reservoir temperature
11412 from January to August (analysis was not performed September to December) would range
11413 from 3.5°C in March to 11.3°C in August. Reservoir water temperatures would be suitable for
11414 bull trout under the No Action Alternative.

11415 Water temperatures in the reservoir also influence temperatures in the Kootenai River
11416 downstream of Libby Dam. Libby Dam discharge water temperature is manageable seasonally
11417 when the reservoir stratifies. During this time, a selective withdrawal system is used to release
11418 water from the reservoir forebay that is closer in temperature to what would have been the
11419 normal water temperature before the dam was constructed (Corps unpublished). Under the No
11420 Action Alternative, the mean monthly temperature of the discharge water from Libby Dam
11421 from January to August was assumed to be the same as for the water temperature in Lake
11422 Kooconusa. Bull trout temperature objectives would be met under the No Action Alternative
11423 from June to December via operation of the selective withdrawal system, though optimal
11424 growth temperature is met only intermittently via use of the selective withdrawal system.
11425 However, the No Action Alternative does not provide the ability to meet temperature
11426 objectives during late winter through late spring because the reservoir is no longer stratified. In
11427 addition, the amount of heat that the water in the reservoir can hold at the over-winter
11428 elevation would dictate the Libby Dam discharge temperature.

11429 Discharges from Libby Dam would affect habitats for bull trout in the Kootenai River below the
11430 dam. Maximum high flows greater than or equal to 20 kcfs are needed seasonally during the
11431 spring freshet period of May 15 through June 15 to flush and sort fine sediments and gravels.
11432 These flows promote macroinvertebrate production and inundate productive varial zone
11433 habitats (i.e., the edges of the reservoir that alternate between being wet and dry depending
11434 on the reservoir water levels; see the Macroinvertebrates section below). Under the No Action
11435 Alternative through the *Kootenai River Operations for Bull Trout* measure, Libby Dam would
11436 provide a discharge of 20 kcfs or greater for 11 to 16 days (25th to 75th percentile) during the
11437 spring freshet. The mean flow rate would be 18.2 to 20.8 kcfs, with a peak discharge of 23.1 to
11438 26.9 kcfs. This would support seasonal flow objectives for flushing and sorting sediments and
11439 gravels. However, these higher flows are insufficient to reshape tributary deltas that have been
11440 formed by excessive tributary bedload and insufficient river discharge. These deltas can prevent
11441 bull trout access during the fall (low river flow) spawning season (Marotz et al. 1996; Hauer et
11442 al. 2016).

11443 Food availability for bull trout, off-channel inundation, and connectivity would be optimized
11444 with discharges of 9 to 12 kcfs from Libby Dam during the minimum flow requirement period
11445 for bull trout of May 15 to September 30 (Hoffman et al. 2002; Marotz et al. 1996; USFWS
11446 2006). The No Action Alternative would provide a median discharge of 10.7 to 15.1 kcfs during
11447 this period; therefore, this alternative would support varial zone and off-channel inundation
11448 and productivity objectives for bull trout.

11449 Kootenai River White Sturgeon

11450 Important operational relationships affecting Kootenai River white sturgeon in this basin are
11451 related to how discharge and temperature affect spawning behavior and location, as well as
11452 egg development. The more prolonged the peak discharge is between mid-May and mid-July,
11453 the greater the probability of adult Kootenai sturgeon moving to spawning areas and
11454 successfully spawning (USFWS 2006; IDFG unpublished data; Ross et al. 2018). The number of

11455 consecutive days of high/prolonged discharge of 30 kcfs or greater at Bonners Ferry was used
11456 to determine the ability of the alternative to provide desirable conditions for Kootenai sturgeon
11457 spawning. The No Action Alternative would provide an average of 19 consecutive days of peak
11458 discharge greater than or equal to 30 kcfs at Bonners Ferry between May 15 and July 15 under
11459 the *Sturgeon Operations at Libby Project* measure.

11460 Water temperatures downstream of Libby Dam are influenced by the water temperatures in
11461 Lake Koochanusa and are important in inducing sturgeon spawning. Higher pool elevations
11462 through the winter associated with system flood risk management protocols can result in colder
11463 water that warms more slowly than optimal during spring and early summer, which in turn
11464 results in cooler and more variable discharge temperatures (personal communication, Hoffman
11465 2019). Lower pool elevation in the winter can result in faster springtime warming of the
11466 forebay, and warmer, less variable discharge temperatures during spring and early summer.
11467 Warmer water (8.5°C to 12°C) is needed in late-May through late-June for sturgeon spawning
11468 (Paragamian and Wakkinen 2011). Egg deposition generally occurs at temperatures greater
11469 than 8°C with a peak at about 9.5°C (Paragamian and Wakkinen 2011). Under the No Action
11470 Alternative, the median mean reservoir water temperature for spring and early summer at Lake
11471 Koochanusa are 3.5°C in March, 3.79°C in April, 6.22°C in May, 9.17°C in June, and 10.78°C in
11472 July. The mean water temperature discharged from Libby Dam under the No Action Alternative
11473 meets temperature objectives in June but is still too cold in May. In addition, this alternative
11474 would not meet the pre-spawning temperature objectives for productivity because over-winter
11475 reservoir volumes influence reservoir temperature (see previous temperature discussion).

11476 In a similar way, water temperatures further downstream at Bonners Ferry are also important
11477 in determining the potential for Kootenai sturgeon spawning. The same water temperatures
11478 are required for successful spawning and egg deposition. Under the No Action Alternative, the
11479 mean monthly temperatures at Bonners Ferry are approximately 2°C warmer than below Libby
11480 Dam (8.3°C in May, 11.1°C in June, and 13.5°C in July) and would be more conducive to
11481 successful sturgeon spawning at this site.

11482 Water temperature affects incubation and larval development. Pre-dam temperatures in the
11483 Kootenai River were consistently cold November to March, and then rose sharply in April and
11484 May. Higher water temperatures reduce incubation time (Paragamian and Wakkinen 2011).
11485 Water temperatures of about 6°C in mid-March that increase to about 14°C by the end of June
11486 are needed for proper development of sturgeon (Hardy and Young, unpublished). Under the No
11487 Action Alternative, the mean monthly water temperature at Bonners Ferry would be below
11488 those temperatures, ranging from 3.8°C in March to 11.1°C in mid-June. This would not support
11489 development of post-hatch larval and juvenile sturgeon.

11490 Bonners Ferry peak flows and the duration of high flows can provide connectivity to backwater
11491 and slough habitats that are important for Kootenai sturgeon larval and juvenile rearing. These
11492 flows provide warmer water over inundated, productive floodplains that provide better
11493 conditions for sturgeon development and growth. Any increase in access to side channel and
11494 floodplain habitats would be beneficial to sturgeon. The number of days that water levels were

11495 above 1,758 feet at Bonners Ferry was used to evaluate the extent of inundation under each
11496 alternative. The greater the number of days that water levels are above this elevation, the
11497 greater the extent of inundation. Under the No Action Alternative, the river would be above
11498 elevation 1,758 feet at Bonners Ferry for an average of 17 days during the sturgeon spawning
11499 period. The No Action Alternative would provide for some unknown level of larval and juvenile
11500 sturgeon rearing habitat.

11501 Other Fish

11502 Entrainment of young-of-year and adult kokanee through Libby Dam results in adverse effects
11503 to kokanee populations. Peak entrainment densities can occur from early spring into mid-
11504 summer, and during fall through early winter (Skaar et al. 1996), depending on kokanee density
11505 and distribution in the forebay. Higher discharges are correlated with higher entrainment. Fish
11506 entrainment rates increase with higher discharge rates.

11507 Many effects to habitat conditions for rainbow/redband trout and westslope cutthroat trout
11508 under the No Action Alternative would be similar to those for bull trout. As with bull trout,
11509 important operational relationships affecting rainbow/redband trout and westslope cutthroat
11510 trout habitat in this basin are related to how reservoir elevations in Lake Koochanusa affect
11511 productivity and food organisms in the reservoir, how reservoir temperatures influence
11512 discharge temperature, and how discharge shape and volume influence habitat suitability in the
11513 river downstream of Libby Dam.

11514 Higher reservoir elevations in the warm summer months would provide a larger euphotic zone
11515 where primary production and zooplankton production would occur in Lake Koochanusa. As with
11516 bull trout, the westslope cutthroat trout food base relies on this production for food the
11517 following winter. The expected increase in productivity from a larger body of warm water
11518 would likely have a beneficial effect on westslope cutthroat trout growth and/or survival
11519 (Marotz et al. 1996).

11520 The effect of the minimum elevation of Lake Koochanusa under the No Action Alternative would
11521 be the same for rainbow/redband trout and westslope cutthroat trout as for bull trout. The
11522 higher the minimum elevation, the greater the insect larvae production and the more food
11523 available for juvenile westslope cutthroat trout (Marotz et al. 1996; Chisholm et al. 1989). The
11524 median minimum reservoir elevation under the No Action Alternative would be 2,366 feet.

11525 The effect of the maximum elevation of Lake Koochanusa as related to volume, surface area, and
11526 proximity of the reservoir surface to terrestrial insect deposition would be the same for
11527 rainbow/redband trout and westslope cutthroat trout under the No Action Alternative as for
11528 bull trout. Under the No Action Alternative, this elevation would typically be 2453.1 in early
11529 August during median years.

11530 Rainbow/redband trout and westslope cutthroat trout optimal growth occurs at 13.1°C and
11531 13.6°C, respectively (Bear et al. 2007). Under the No Action Alternative, the mean monthly
11532 (water column mean) reservoir temperature from January to August (September to December
11533 were not analyzed) would range from 3.5°C in March to 11.3°C in August. This indicates the No

11534 Action Alternative does provide the ability to meet temperature objectives for
11535 rainbow/redband trout and westslope cutthroat trout in the reservoir, as fish would be able to
11536 find the preferred temperatures they seek.

11537 Libby Dam discharge water temperature is manageable seasonally (when the reservoir
11538 stratifies) using the selective withdrawal system to release water from the reservoir forebay
11539 that is closer to pre-dam river temperatures. The No Action Alternative would continue to
11540 provide the ability to meet temperature objectives for rainbow/redband trout and westslope
11541 cutthroat trout during early summer through early winter (June to December) via operation of
11542 the selective withdrawal system. However, the No Action Alternative does not provide the
11543 ability to meet temperature objectives during late winter through late spring, as the reservoir
11544 would be isothermic.

11545 Discharges from Libby Dam would have the same effect on habitat for rainbow/redband and
11546 westslope cutthroat trout as for bull trout in the Kootenai River downstream from the dam.
11547 Maximum high discharges greater than or equal to 20 kcfs are needed annually during the
11548 spring freshet period to flush and sort fine sediments and gravels. Higher discharges (up to 25+
11549 kcfs) of longer duration (up to 30+ days) are desired. Under the No Action Alternative, Libby
11550 Dam would provide discharges of 20 kcfs or greater for 11 to 16 days (25th to 75th percentile)
11551 during the spring freshet. This would support seasonal flow objectives for flushing and sorting
11552 sediments and gravels in the river below Libby Dam

11553 Dewatering the varial zone of the Kootenai River during the productive season (June to
11554 September) reduces the density of the benthic invertebrate community. Benthic organisms die in
11555 less than 5 days in the dewatered zone, and it takes over a month and a half for them to recover
11556 after the substrate becomes re-wetted (Oasis Environmental 2011; Marotz and Althen 2005).

11557 Under the No Action Alternative, winter operations at Libby Dam would continue to have
11558 winter ramping rates that are less protective than spring and summer rates, allowing for varial
11559 zone desiccation, re-inundation, and freezing. This may affect species bioenergetics and
11560 increase their metabolic activity and would be deleterious to benthic ecology, which would
11561 affect food organisms for rainbow/redband and westslope cutthroat trout. As mentioned under
11562 bull trout, no data are available to assess the within-day variability of the flows, and therefore
11563 this effect was not evaluated for any of the MOs.

11564 Off-channel habitats are important for larval and juvenile burbot in the lower Kootenai River.
11565 These habitats provide warmer water, cover, and important forage. Similar to Kootenai River
11566 white sturgeon, the number of days that water levels were above 1,758 feet at Bonners Ferry
11567 was used to evaluate inundation under each alternative. The No Action Alternative would
11568 provide a median of 17 days above this elevation during the larval emergence and development
11569 stages of burbot, providing access to warmer and more productive rearing habitats for these
11570 days. This alternative would provide some floodplain connectivity for burbot; however, larval
11571 and juvenile burbot would benefit from an even longer duration of inundation.

11572 Pre-dam flows and temperatures in the Kootenai River from November to March were low,
11573 stable, and cold. Burbot required these conditions for successful spawning and migration.
11574 Stable flows around of about 4 kcfs result in spawning congregations (based on empirical catch
11575 rates; IDFG cite), while daily load shaping and weekly load following result in high and variable
11576 flows and interrupted spawning migrations of adult burbot (Paragamian et al. 2005; Ross et al.
11577 2018; Ashton et al. in press).

11578 The modeled mean, maximum, and minimum flow at Bonners Ferry between January 1 and
11579 April 30 was used to represent the flow variability under each alternative. Under the No Action
11580 Alternative, the mean flow would be 13.4 kcfs, with an average maximum and an average
11581 minimum flow of 29.4 kcfs and 5.5 kcfs, respectively. Under the No Action Alternative, flows
11582 would not provide the appropriate discharge regime for successful burbot recruitment.

11583 Water temperature is important for burbot egg incubation and larval development. Pre-dam
11584 temperatures in the Kootenai River were consistently cold November through March, and then
11585 rose sharply in April and May. Because discharge temperatures are too cold, and access to
11586 sufficient floodplain areas is limited, larval development is slowed and mortality increased.

11587 Burbot need water temperatures of about 2°C in mid-February for spawning, egg incubation,
11588 and survival. Following spawning and early incubation, these fish need water temperatures to
11589 increase at a rate of over 2°C each month until they reach about 14°C by the end of June for
11590 normal development. Under the No Action Alternative, the mean monthly water temperature
11591 at Bonners Ferry would be below those temperatures, ranging from 3.88°F in March 11.1°C in
11592 mid-June. These temperatures would not provide appropriate mean monthly temperatures at
11593 Bonners Ferry for development of burbot. Early winter temperature would often be too warm
11594 for spawning and egg development and too cold for proper body development, growth, and
11595 survival.

11596 A potential adverse effect on burbot is the entrainment of eggs and larval burbot through Libby
11597 Dam during March and early April. Although not explicitly quantified, the lower the discharge,
11598 the fewer the number of eggs and larvae would be entrained (Skaar et al. 1996). Modeling
11599 results show the median Libby Dam discharge between March 1 and April 15 would be 4 to 11
11600 kcfs under the No Action Alternative; the effects of this discharge are not quantifiable.

11601 ***Hungry Horse/Flathead/Clark Fork Fish Communities***

11602 Summary of Key Effects

11603 Hungry Horse Reservoir is a naturally cold, nutrient-poor reservoir; as such it has poor algae and
11604 zooplankton production but typically good water quality. Successful reproduction drives fish
11605 populations, but food availability is very important. Many of the important relationships
11606 between operations and fish in the reservoir focus on primary and secondary food production
11607 and the entrainment of both fish and zooplankton out of Hungry Horse Reservoir. In addition to
11608 these effects, reservoir elevations also influence the ability of migrating fish to access
11609 tributaries to spawn, and lower lake elevations increase the risk of predation and angling

11610 exploitation fishing on these fish in the varial zone. In the river below Hungry Horse, changes in
11611 temperatures and flows due to dam operations influence habitat suitability, and these effects
11612 continue downstream to the mainstem Flathead River and into Flathead Lake, then beyond into
11613 the lower Flathead River and Clark Fork River.

11614 Habitat Effects Common to This Fish Community

11615 Hungry Horse operations influence food web production in several ways:

- 11616 • Lake elevations in the warm summer months influence the volume of warm, productive
11617 water for primary production and zooplankton production. This primary production in the
11618 summer provides food for the zooplankton that become an important food source for fish
11619 the following fall and winter (Fraley and Graham 1982, Fraley and Shepard 1989).
- 11620 • The magnitude and rate of reservoir drawdown influences the production of benthic insects
11621 on the reservoir bottom from the water's edge down as far as light can penetrate. Insects
11622 need five to seven weeks of wetted substrate with light penetration in order to be
11623 productive. If areas are dewatered before this process is complete, there is no production.
11624 Higher reservoir levels also provide for inundation of the large flat shallow areas at the
11625 upper end of the reservoir to be productive with aquatic insects. These are an important
11626 food source in the spring (May et al. 1988).
- 11627 • Reservoir elevations influence the availability of terrestrial insects for fish. This is an
11628 important summer food source. Lower lake elevations equate to less surface area for these
11629 insects to land on the water and be eaten by fish. Further, two of the four orders of insects
11630 that are this food source (flies, bees, and wasps) are able to fly so they readily transport to
11631 the water surface, but the other two (beetles and leafhoppers) do not fly, so as the water
11632 recedes away from the terrestrial vegetation, these food items become less available as
11633 they simply drop to the ground rather than dropping in the water (May et al. 1988).
- 11634 • Outflows, elevations, and the location of water withdrawal affect the loss of zooplankton
11635 through entrainment out of the dam and into the South Fork Flathead River (Cavigli et al.
11636 1998).

11637 Lake elevations also influence the ability of fish to access tributaries for spawning, as most
11638 species migrate upstream into these inflowing streams to spawn. At elevations near the top of
11639 the normal pool, there is generally good access into the tributaries directly from the lake. As
11640 elevations drop, fish must traverse a length of tributary flowing through the varial zone, or
11641 where previous inundation has resulted in sedimentation and lack of vegetation. In these areas,
11642 fish are more susceptible to predation, angling pressure, and reduced access to tributaries.

11643 Lake elevation in the warm summer months determines the volume of reservoir that would be
11644 available to produce plankton (euphotic zone). Note as the summer goes on, this productive
11645 zone gets thicker. This was estimated by determining the modeled reservoir elevation at the
11646 end of each month, converting it to reservoir volume, then subtracting the volume of the
11647 reservoir lower zone that would not produce plankton. See Appendix F for additional detail.

11648 Drawdowns through the summer affect this production as well as the production of insects that
11649 live on the bottom of the reservoir. As reservoir elevations drop, insects in this zone can become
11650 dewatered. The insect eggs would have been deposited within the euphotic zone described
11651 above. If reservoir levels drop, that zone remains the same thickness and drops with the surface
11652 level, but there would be no insects deposited at the lower elevation that is now the euphotic
11653 zone, so steeper drops in the elevation relate to less benthic insect production. In addition, the
11654 large bays at the upper end of the reservoir become dewatered with dropping levels over the
11655 summer. This would continue to result in the loss of some benthic insect production but would
11656 continue to be enough to support a healthy native fish community. Additionally, there are three
11657 lobes of the reservoir with different shapes that would tend to become dewatered at different
11658 rates; they are known as Emery (the main lobe towards the dam), Murray, and Sullivan.

11659 The reservoir elevation determines the surface area available for terrestrial insects to land on
11660 the water and be available for fish food, as well as influencing the proximity of the water's edge
11661 to terrestrial vegetation and therefore the ability of the two non-flying orders of important
11662 insects to be available to fish by passively landing in the water. To evaluate the No Action
11663 Alternative, the end-of-month elevation was converted to surface area using bathymetric data
11664 (USBR unpublished data). See Appendix F for end-of-month surface area calculations.

11665 Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry
11666 Horse Reservoir. The zooplankton enhances food supply in the South Fork Flathead River and
11667 along the near bank of the Flathead River but decreases food supply for fish in Hungry Horse
11668 Reservoir. Outflows, and therefore entrainment rates, are lower in the winter when the
11669 zooplankton are most important for fish.

11670 Outflow patterns can also affect how fish are entrained into the South Fork Flathead River and
11671 the habitat conditions, such as river elevation (stage), velocities, and temperatures in the river.
11672 These effects continue downstream to affect the main Flathead River in the same patterns, but
11673 are somewhat attenuated by the flows in the mainstem Flathead River. Temperatures in
11674 summer are regulated with a selective withdrawal structure that is operated to release water at
11675 a temperature that favors native fish.

11676 In the Flathead River down to Flathead Lake, habitat suitability is a key issue due to unnaturally
11677 high flows in the summer and winter. Under the No Action Alternative, summer flows would
11678 continue to be higher than natural, resulting in velocities that can be difficult for bull trout and
11679 other native fish, but the river would continue to provide habitat to support them. Higher-than-
11680 normal winter flows would continue to limit establishment of riparian vegetation important to
11681 fish. Spring peaks, although lower than natural, would continue to occasionally provide flushing
11682 of sediments from gravel to enhance production of benthic food sources.

11683 Temperatures in the Flathead River would continue to be influenced by the contribution of the
11684 South Fork Flathead River with normalized temperatures in summer, when the selective
11685 withdrawal system operates. In the winter, the selective withdrawal structure is not operated
11686 so no longer useful to release targeted temperatures, but, in the winter, the reservoir is
11687 warmer than mainstem Flathead and so releases during this period are warmer than what

11688 would be normal. TDG in the Flathead River would continue to fluctuate with spill at Hungry
11689 Horse Dam but generally would not exceed 117 percent, which is within a safe zone for fish,
11690 under the *Operations to Limit TDG Production at the Hungry Horse Project* measure.

11691 The influence of project operations on Seli's Ksanka Qlispe' Dam and outflows Flathead Lake
11692 elevations is minor but could influence fish in the lower Flathead River and the Clark Fork River.
11693 Winter base flows out of Seli's Ksanka Qlispe' Dam would typically be stable at about 7,700 cfs
11694 in January under the No Action Alternative, and summer flows are also artificially high.

11695 Bull Trout

11696 Hungry Horse Reservoir and its associated upstream tributaries support one of the healthiest
11697 populations of bull trout in their range. The productivity conditions described above as the No
11698 Action Alternative would continue to support this food web and bull trout. Reservoir elevations
11699 influence the access to spawning tributaries and the degree of varial zone effects, such as
11700 predation risk and exposure to angling exploitation that fish experience. Bull trout spawn in the
11701 fall. Changes in reservoir operations implemented in 2009 have reduced water level fluctuation
11702 during the summer and fall, which overlaps with the primary period when bull trout are
11703 migrating to spawning and overwintering habitats in tributaries (Reclamation 2009). In most
11704 years, tributary access and predation exposure and angling pressure in the varial zone are
11705 typically not an issue. The No Action Alternative would continue to provide access to spawning
11706 tributaries and limit varial zone effects. This could become a problem in low water years.

11707 Bull trout entrainment through the dam is known to occur but the extent of entrainment has
11708 not been studied and the overall effect to populations is not known. It would be expected to
11709 continue at similar levels that do not impact overall populations. Bull trout are known to be
11710 present at depths greater than 100 feet near the dam and would be susceptible to being swept
11711 through the dam (i.e., entrainment), especially as the lake stratifies in the summer.

11712 Bull trout in the South Fork Flathead River below Hungry Horse Reservoir are typically limited to
11713 either individuals entrained out of Hungry Horse or transitional use by individuals from the
11714 mainstem Flathead River, typically in October to July. There is not a spawning population in this
11715 stretch from Hungry Horse dam to the confluence with the Flathead River, and it is not
11716 designated critical habitat (FR 63898). As in the reservoir, food web relationships are important.
11717 The No Action Alternative would continue to allow for this transitory use by bull trout and other
11718 native fish with adequate food. Established minimum flows would continue to protect habitat,
11719 and ramping rate restrictions limit fluctuations.

11720 The mainstem Flathead River would continue to provide conditions suitable for bull trout, with
11721 somewhat normalized temperatures, higher summer flows limiting slow-velocity habitat in
11722 summer, and higher winter flows limiting production of riparian vegetation.

11723 Seli's Ksanka Qlispe' Dam (Flathead Lake) operations would continue to potentially influence
11724 bull trout by occasional erosion events, causing water quality effects and favoring non-native
11725 fish such as northern pike in the bays and sloughs at the top of Flathead Lake. Bull trout use of

11726 Flathead Lake would continue, and there could be some entrainment of bull trout at Seli's
11727 Ksanka Qlispe' Dam into the lower Flathead River, particularly in cooler months when the
11728 temperatures would not exclude them from the large lobe of the lake near the outlet, though
11729 the extent is not known. Finally, the operations would continue to provide the flow regime to
11730 Seli's Ksanka Qlispe' to operations downstream that support small, highly fragmented bull trout
11731 populations limited by dams and reservoirs influence on temperatures, flows, and non-native
11732 species on downstream in the Clark Fork River.

11733 Other Fish

11734 Hungry Horse Reservoir, as described in Section 3.5.1.4, favors a native-fish-dominated fish
11735 community. Juvenile bull trout and adult whitefish, northern pikeminnow, sculpins, and
11736 westslope cutthroat trout feed on zooplankton, aquatic insects, and terrestrial insects, and
11737 adult bull trout prey on mountain whitefish, suckers, and minnows. The food web effects
11738 described above would also apply to these species of fish in Hungry Horse Reservoir.

11739 Westslope cutthroat trout and other native fish spawn in the spring (April to June), so the
11740 effects on adults migrating into tributaries to spawn would differ from bull trout. Spring
11741 spawning fish migrate when reservoir levels are lower and tend to experience longer varial
11742 zones with increased predation exposure, but access to tributaries is not typically problematic
11743 in most years.

11744 Entrainment from the reservoir would also continue at current, unquantified levels, though
11745 westslope cutthroat trout would not be expected to be as susceptible as bull trout because they
11746 are not found at the depths of outlets like bull trout. Operations rules (VarQ), ramping rate
11747 restrictions, and minimum flows would continue to support the observed increasing trends of
11748 native fish and limit invasion by lake trout and brook trout.

11749 A selective withdrawal structure and VarQ rules would continue to regulate temperatures to
11750 support a more natural thermal regime that is beneficial to native fish and minimize invasion by
11751 non-native fish such as lake trout from Flathead Lake. Westslope cutthroat trout in the Flathead
11752 River would continue to move up into the South Fork Flathead River when the temperature
11753 control structures operate. In Flathead Lake, northern pike are nearly beyond the time when
11754 their eggs would still be viable by the time the lake levels rise far enough for them to access
11755 spawning areas in bays, and further delay in refill could reduce their spawning success. Some
11756 entrainment out of Flathead Lake likely occurs but is unquantified.

11757 Below Seli's Ksanka Qlispe' Dam in the lower Flathead River and Clark Fork River, the altered
11758 hydrograph would favor non-native species; the fish community is dominated by non-natives
11759 but some bull trout and westslope cutthroat trout are also present. High winter flows limit
11760 riparian cover, and higher summer flows increase habitat for non-native fish such as walleye
11761 and smallmouth bass.

11762 **Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River**

11763 Summary of Key Effects

11764 The No Action Alternative would not change the way bull trout are currently utilizing Lake Pend
11765 Oreille or the Pend Oreille River downstream of Albeni Falls Dam. Bull trout would continue to
11766 use Lake Pend Oreille from November to June when water temperatures are cooler, then move
11767 into tributaries in the summer. Sub-adult bull trout and non-spawning adults may remain and
11768 rear in the lake year-round. An unknown number of bull trout would be entrained at Albeni
11769 Falls Dam. These fish would likely perish in the summer when water temperatures in the river
11770 downstream of the dam reach lethal levels, although a small number (between 1-12 per year)
11771 may be recovered by temporary efforts to collect fish from the tailrace. A permanent trap and
11772 haul fishway may be completed during the period of analysis for the EIS. Kokanee would
11773 continue to be able to spawn, but their populations would be influenced by competition with
11774 opossum shrimp for food (zooplankton) coupled with predation by lake trout and other
11775 predatory fish species. Westslope cutthroat trout would continue to use Lake Pend Oreille, and
11776 an unknown number would be entrained at Albeni Falls Dam. Like bull trout, they would likely
11777 experience high mortality rates in the summer when water temperatures in the river
11778 downstream of the dam reach lethal levels. Some may be recovered by trap and haul efforts.
11779 Key effects for warmwater game fish such as pike, walleye, and smallmouth bass include stable
11780 spring water levels for spawning and rearing, winter drawdowns that interrupt juvenile rearing,
11781 adequate forage for large predators, and potential entrainment.

11782 Habitat Effects Common to This Fish Community

11783 As discussed in Appendix D, *Water Quality, 7-3, Albeni Falls*, temperature data collected in the
11784 lake in 2004 to 2006 showed surface water temperatures typically exceed 19°C by the end of
11785 June and reach a maximum of 24°C at the end of July. At depths below 14 m, temperatures are
11786 within the preferred range of bull trout during summer (less than 15°C). Colder water of 5°C
11787 and below is found throughout the summer in some locations. These water temperature
11788 patterns would be expected to continue under the No Action Alternative. The river section of
11789 Lake Pend Oreille does not provide cool water refugia. This is because the shallow low-water
11790 channel near Sandpoint, Idaho, acts as a heat source for downstream flows and blocks the
11791 movement of much colder subsurface water from Lake Pend Oreille into the river section. Large
11792 woody debris is not currently allowed to enter Lake Pend Oreille as it poses a safety hazard to
11793 boating. A log boom currently diverts debris coming into the lake.

11794 Outflows from Albeni Falls Dam would affect rates of entrainment of fish from Lake Pend
11795 Oreille. Mean flows under the No Action Alternative in May and June would be about 50,700
11796 and 55,600 cfs, respectively. Under the No Action Alternative, median flows are 23,700 cfs in
11797 October to draft Lake Pend Oreille. In the winter, median discharge is 14,500 cfs to 16,600 cfs.
11798 River temperatures below Albeni Falls Dam are expected to be similar to those in the river part
11799 of Lake Pend Oreille above the dam. These temperatures reach 15°C in June and lethal
11800 temperatures for cold water fish in July (Corps 2018). Under the No Action Alternative, these
11801 high summer water temperatures are expected to continue.

11802 Bull Trout

11803 Access to tributaries is important for bull trout in Lake Pend Oreille, as that is where they
11804 spawn. Under the No Action Alternative, bull trout would continue to have access to tributaries
11805 to Lake Pend Oreille during the spring and summer. Bull trout move into the tributaries when
11806 lake levels are high during May and June. Because Albeni Falls Dam operations affect
11807 sedimentation and erosion from the lake shorelines, this could indirectly affect bull trout access
11808 to tributary mouths due to sedimentation. During the upstream migration of bull trout in May
11809 to September, the pool elevation is rising or at the full pool elevation of 2,062 feet under the
11810 *Lake Pend Oreille Elevations for Kokanee and Bull Trout* measure. Gold and Granite Creeks may
11811 be affected more as fish move into these tributaries later in the year. However, current
11812 operations rarely affect tributary access during spring and summer (Corps 2018). Operations
11813 under the No Action Alternative would continue to provide access to most tributaries for bull
11814 trout.

11815 Historically, bull trout from Lake Pend Oreille would migrate up the Clark Fork and spawn. The
11816 construction of Cabinet Gorge Dam on the Clark Fork in 1953 blocked those runs, and the
11817 genetics for that population may have been lost. In 2001, a trap-and-haul operation was
11818 implemented to capture adult bull trout at Cabinet Gorge Dam and transport them to sites
11819 upstream. On average approximately 35 adult bull trout are transported at this site each year.
11820 The design for an updated permanent fish trap at Cabinet Gorge Dam was finalized in 2018
11821 (Avista 2017). Under the No Action Alternative, bull trout from the lake would continue to have
11822 passage to their historic habitat above Cabinet Gorge Dam, either from the trap-and-haul
11823 program or the new permanent fish trap.

11824 An unknown number of bull trout are entrained through Albeni Falls Dam each year and are
11825 lost to the system, as there currently is no trap-and-haul program at Albeni Falls Dam to return
11826 them to the lake. However, a permanent trap and haul fishway may be completed during the
11827 period of analysis for the EIS that would allow these fish to return upstream. Entrainment is
11828 most common from March to June when flows are high (Corps 2018). Most populations of bull
11829 trout within Lake Pend Oreille are large enough that there are not likely to be major effects
11830 from entrainment. Entrainment is likely to continue under the No Action Alternative, with trap
11831 and haul reducing the number of fish lost in the future.

11832 Under the No Action Alternative, water temperatures in Lake Pend Oreille would continue to be
11833 suitable for bull trout year-round in at least part of the lake. Bull trout prefer cold water with
11834 temperatures below 15°C (Barrows et al. 2016). In November through June when bull trout are
11835 present in the lake, surface temperatures range from about 4°C to 15°C, while temperatures in
11836 deeper water greater than about 65.6 feet (20 m) rarely exceed 15°C. In June to October,
11837 surface water temperatures would likely be too warm for bull trout (greater than 18°C), but
11838 deeper parts of the lake below the thermocline 45 ft. (14 m) or greater, would still provide cold
11839 water habitat (less than 15°C) suitable for bull trout. Temperature profiles from Appendix D
11840 show that water temperatures between June and October are likely too hot for bull trout in the
11841 river section of Lake Pend Oreille. This is because a shallow low-water channel near Sandpoint,
11842 Idaho, acts as a heat source for downstream flows and blocks the movement of much colder

11843 subsurface water from Lake Pend Oreille into the river section. This is likely to continue under
11844 the No Action Alternative.

11845 The continuing loss of large woody debris along the shoreline is not likely to adversely affect
11846 bull trout; historically this debris settled out in shallow water habitat that has warmer surface
11847 water and is not likely to be used by bull trout.

11848 Lake Pend Oreille would continue to provide adequate forage for bull trout under the No Action
11849 Alternative. Bull trout need robust kokanee populations for adequate forage as kokanee are the
11850 principal prey for adult bull trout (Hansen et al. 2019). Under current conditions, kokanee
11851 would continue to provide a good forage base for adult bull trout. Kokanee have increased from
11852 about 40 adult fish per acre (100 adult fish per hectare) in 2008 to about 152 adults per acre
11853 (377 adults per hectare) in 2016 (Hansen et al. 2019). Winter fluctuations are likely to increase
11854 erosion of the lakebed at lower elevations of about 2,051 to 2,056 feet and may affect forage
11855 fish production (Corps and Bonneville 2011).

11856 Under the No Action Alternative, bull trout may experience greater predation and competition
11857 for food from walleye, northern pike, and lake trout. Walleye populations have been at a low
11858 level but are now expanding rapidly. From 2011 to 2017, relative abundance has doubled every
11859 3 years (reference to be added prior to final). There is recruitment of walleye in Lake Pend
11860 Oreille as well as entrainment from upriver. Operations of Albeni Falls Dam and the lake may
11861 favor walleye and other warmwater fish during the time that bull trout subadults are migrating
11862 downstream into Lake Pend Oreille through the river/lake interface. Under current conditions,
11863 walleye populations are expected to expand and prey on sub-adult bull trout. Walleye also
11864 forage on kokanee, and therefore would compete with adult bull trout for this important food
11865 source.

11866 Northern pike would also prey upon and compete with bull trout, but the actual effect under
11867 the No Action Alternative is undetermined. Studies in Montana show that northern pike eat bull
11868 trout (Muhlfield et al. 2008). Bull trout and westslope cutthroat trout make up about 5 percent
11869 of the diet of northern pike in upriver sites. Northern pike also prey on kokanee. While
11870 northern pike enter Lake Pend Oreille from upstream entrainment and in-lake recruitment,
11871 their numbers are still low and their future populations are undetermined.

11872 Lake trout compete with bull trout for kokanee in Lake Pend Oreille. A lake trout suppression
11873 program in effect from 2006 to 2016 was successful in removing many lake trout from the lake
11874 and, consequently, kokanee populations have increased (Hansen et al. 2019). However, bull
11875 trout populations remained low and bull trout redd counts are down. Under the No Action
11876 Alternative, competition from lake trout is expected to continue at low levels in the lake.

11877 There is a potential indirect effect to bull trout from hybridizing with brook trout populations.
11878 However, brook trout populations are primarily found in the tributaries, and only limited
11879 populations are found in the mainstem habitats.

11880 Downstream of Albeni Falls Dam, non-native Northern pike and walleye have expanded their
11881 populations and may consume bull trout there. Northern pike are the apex predator in this
11882 system and are experiencing exponential population growth (reference to be added prior to
11883 final). Suppression efforts started in 2012 in Box Canyon reservoir, the first reservoir
11884 downstream of Albeni Falls Dam, have resulted in a 90 percent reduction in northern pike
11885 (reference to be added prior to final). Suppression efforts have also started at Boundary Dam,
11886 which is downstream of Box Canyon Dam. However, suppression efforts would not eliminate
11887 northern pike from the river, and the remaining fish could prey on entrained bull trout. This
11888 predation would not affect bull trout populations as any entrained bull trout would not be able
11889 to return upstream of the dam to spawn and would not survive the high water temperatures in
11890 the summer. Walleye have also expanded their populations in both Box Canyon and Boundary
11891 Reservoirs, but their numbers are still relatively low. Predation by walleye would have the same
11892 effect on bull trout as for northern pike under the No Action Alternative.

11893 Other Fish

11894 Under the No Action Alternative, kokanee would continue to be able to spawn, but their
11895 populations would be influenced by competition with opossum shrimp for food (zooplankton)
11896 coupled with predation by lake trout and other predatory fish species. The operation to
11897 manage winter lake elevations behind Albeni Falls Dam is, in part designed to support kokanee
11898 spawning and egg incubation in Lake Pend Oreille under the *Lake Pend Oreille Elevations for*
11899 *Kokanee and Bull Trout* measure. The intent is to lower the lake to its winter elevation before
11900 kokanee start spawning along the shoreline in November and December and hold it there
11901 through March to prevent dewatering of the redds during egg incubation. Flexible winter power
11902 operations (power peaking) result in changing lake elevations in the winter and may increase
11903 erosion of kokanee spawning habitat. While the modeling used for evaluating reservoir
11904 elevations cannot show power peaking operations, the current lake operations do not appear
11905 to adversely affect kokanee spawning or egg incubation. Relatively low numbers of kokanee
11906 would continue to be entrained through Albeni Falls Dam under the No Action Alternative.
11907 Entrainment most likely occurs during high flows but is not likely a large source of loss to the
11908 population of kokanee in Lake Pend Oreille (Bellgraph et al. 2015). Sampling by the Kalispel
11909 Tribe shows a limited number of kokanee downstream of Albeni Falls Dam. Kokanee have also
11910 been seen in the reservoirs behind Box Canyon Dam and Boundary Dam following high-flow
11911 events (personal communication, Bill Baker, WDFW).

11912 Under the No Action Alternative, kokanee populations in Lake Pend Oreille would continue to
11913 be influenced by competition with opossum shrimp and predation by lake trout and other
11914 predators (e.g., Gerard rainbow trout, walleye, bull trout) (Corsi et al. 2019). Both opossum
11915 shrimp and kokanee feed on zooplankton, and high shrimp numbers reduce the amount of
11916 forage available to kokanee. At the same time, kokanee are also prey for lake trout, walleye,
11917 and bull trout. To maintain kokanee populations, predator suppression has been used to keep
11918 lake trout numbers down at Lake Pend Oreille, but walleye continue to increase. Opossum
11919 shrimp regulate kokanee population potential while predator populations appear to be the
11920 primary driver for kokanee populations within that potential in Lake Pend Oreille. Kokanee

11921 populations under the No Action Alternative are expected to continue remain at current levels
11922 in the foreseeable future assuming opossum shrimp populations remain low and predator
11923 management continues to be successful. Kokanee are expected to continue to provide forage
11924 for predators, including bull trout, in future years.

11925 As with bull trout, the construction of Cabinet Gorge Dam blocked access to tributaries for
11926 westslope cutthroat trout in Lake Pend Oreille. This blockage resulted in a loss of genetics and
11927 habitat for the species. In 2016, trap-and-haul operations were implemented to capture adult
11928 westslope cutthroat trout at Cabinet Gorge Dam and transport them to upstream sites. As
11929 discussed above for bull trout, the design for a permanent fish trap at the dam was finalized in
11930 2018 (Avista 2017). Under the No Action Alternative, westslope cutthroat trout from the lake
11931 would continue to have passage to their historic habitat above Cabinet Gorge Dam, either from
11932 the trap and haul program or the new permanent fish trap.

11933 Similar to bull trout, an unknown number of westslope cutthroat trout are entrained through
11934 Albeni Falls Dam each year. Cutthroat are found relatively often below the dam and are isolated
11935 from their habitat as there currently is no trap and haul program at the dam to capture fish and
11936 return them to the lake. Cutthroat are cued to spawn when water temperatures reach about
11937 10°C (Liknes and Graham 1988), or about May in Lake Pend Oreille. Entrainment is highest in
11938 May and June during the spring high spill season (Corps 2018) and coincides with when the fish
11939 are moving to spawning areas. Entrainment at Albeni Falls Dam is likely to continue and affect
11940 an unknown number of fish under the No Action Alternative.

11941 As discussed above for bull trout, water temperatures between June and October are likely too
11942 hot for westslope cutthroat trout in the river section of Lake Pend Oreille as well as the river
11943 downstream of Albeni Falls Dam. Bear et al. (2007) found that water temperatures over 18°C
11944 are limiting for westslope cutthroat trout and the upper lethal temperature is about 20°C.
11945 Westslope cutthroat trout in the Pend Oreille River would also continue to be susceptible to
11946 predation from walleye and northern pike.

11947 Walleye in Lake Pend Oreille spawn in the spring over cobble and gravel substrates when water
11948 temperatures reach at least 4°C (reference to be added prior to final). Under the No Action
11949 Alternative, water temperatures in Lake Pend Oreille would range from 3°C in February to 12°C
11950 in May (Appendix D). These temperatures and substrates would continue to support walleye
11951 spawning at Lake Pend Oreille under the No Action Alternative.

11952 Stable water levels are also critical for walleye spawning success, as drawdowns during
11953 spawning would leave eggs and larvae dry. Walleye spawn when Lake Pend Oreille is filling, so
11954 the eggs and larvae would likely remain submerged under the No Action Alternative. Winter
11955 operations can fluctuate as much as 5 feet during early March and may affect a small portion of
11956 the walleye spawn. The effect on walleye spawning under the No Action Alternative is
11957 unknown, but elevated stable water levels may improve summer habitat for walleye.

11958 Walleye fry (young fish that are capable of feeding themselves) are pelagic (living in open
11959 water) and feed on zooplankton. Reduce plankton numbers lead to reduced fry survival. Lake

11960 Pend Oreille is classified as oligotrophic to mesotrophic (low to moderate productivity), and a
11961 moderate number of zooplankton were sampled, with increases in the last 8 years (reference to
11962 be added prior to final). Recent increases in walleye populations is evidence of lack of
11963 limitations to fry survival. Currently plankton numbers do not appear to be limiting for walleye.
11964 This would be expected to continue under the No Action Alternative.

11965 Smallmouth bass spawning in Lake Pend Oreille is initiated when water temperatures reach
11966 about 13°C (Edwards et al. 1983). Under the No Action Alternative, water in Lake Pend Oreille
11967 would reach this temperature in mid-May. Egg development for smallmouth bass requires
11968 temperatures of 13°C to 25°C for normal growth. Surface water temperatures in Lake Pend
11969 Oreille currently reach 13°C in May and rise to over 20°C in July. This indicates the lake currently
11970 provides water temperatures that support smallmouth bass embryo development. This would
11971 continue under the No Action Alternative.

11972 Pool elevation affects spawning, egg development, and fingerling survival for smallmouth bass.
11973 Water fluctuations during spawning and egg incubation (mid-May through June) can reduce
11974 recruitment if the water levels drop and dry up the nests. However, water elevations in Lake
11975 Pend Oreille generally increase from 2,057 to 2,062 feet during this period and therefore do not
11976 adversely affect smallmouth bass spawning or recruitment. This effect would continue under
11977 the No Action Alternative.

11978 Pool elevations in Lake Pend Oreille from May through October may affect smallmouth bass
11979 fingerling survival. Water levels are generally raised from May to June, held constant until
11980 September, and dropped rapidly until mid-November. Under the No Action Alternative, this
11981 pattern of water level management in the lake may adversely affect smallmouth bass fry or
11982 fingerlings at the end of the rearing period in September and October by forcing the fish to
11983 leave nesting and rearing areas.

11984 Pool elevations at Lake Pend Oreille can affect northern pike habitat availability. When the lake
11985 is at full pool, inlet and slough habitats that are optimum habitats for northern pike are
11986 inundated. When water levels drop, these habitats are no longer available. Pool elevations in
11987 Lake Pend Oreille are generally raised from May to July, held constant until September, and
11988 dropped rapidly through October. This operation would continue under the No Action
11989 Alternative and would result in lake levels that would support limited spring spawning and
11990 summer rearing habitat for northern pike.

11991 High flows could affect entrainment at upstream reservoirs and move invasive northern pike
11992 from these reservoirs into Lake Pend Oreille. Flows from Cabinet Gorge Dam during the spring
11993 freshet (May and June) can be used as a surrogate for the risk of northern pike entrainment
11994 into Lake Pend Oreille with higher flows resulting in increased risk of entrainment. Median
11995 flows under then No Action Alternative for May and June would be 50,700 cfs and 55,600 cfs
11996 respectively. Under these flows, continued entrainment of northern pike into Lake Pend Oreille
11997 would be expected.

11998 Mountain whitefish spawn in the Pend Oreille River below Albeni Falls Dam in October. Eggs
11999 and fry require sufficient stable winter flows to prevent desiccation and freezing. Under the No
12000 Action Alternative, median flows are 23,700 cfs in October to draft Lake Pend Oreille. In the
12001 winter, median discharge is 14,500 cfs to 16,600 cfs. As a result, an unknown number of
12002 whitefish eggs and fry are lost during this operation. Under the No Action Alternative, these
12003 losses would continue.

12004 When non-native plants invade littoral zone habitats, changes in biotic and abiotic interactions
12005 often occur (Madsen 1998). Lake Pend Oreille has approximately 20,700 acres of littoral zone
12006 habitat for aquatic plant growth, or about 27 percent of the lake area. Eurasian watermilfoil is
12007 an invasive species that often grows in dense beds that can be responsible for reductions in DO,
12008 increases in water temperature, internal nutrient loading, reduced native plant richness, and
12009 reduced macroinvertebrate abundance and fish growth (Madsen 1998). Currently, milfoil beds
12010 are treated chemically to reduce their abundance and distribution. These treatments have
12011 resulted in a 90 percent reduction in the distribution of this invasive plant. Under the No Action
12012 Alternative, these treatments would continue and milfoil distribution is not expected to
12013 expand.

12014 Game fish, particularly warmwater game fish, require stable water levels during spawning and
12015 rearing to prevent the desiccation of eggs or fry. The No Action Alternative operation would
12016 result in lake levels that would generally support spring spawning and summer rearing for
12017 warmwater game fish. Early winter drawdowns of Lake Pend Oreille can interrupt juvenile
12018 rearing and may reduce numbers of non-native game fish species like largemouth bass,
12019 pumpkinseed, and black crappie. Currently, water levels are dropped at Lake Pend Oreille in
12020 early September through November under the *Lake Pend Oreille Elevations for Kokanee and*
12021 *Bull Trout* measure. This drop would likely interrupt juvenile rearing and reduce successful
12022 recruitment in some years.

12023 Gerrard or Kamloops rainbow trout are an important trophy fishery at Lake Pend Oreille. These
12024 fish grow to large sizes and require robust kokanee populations for adequate forage, as
12025 kokanee are the principal prey for adult rainbow trout. Under the current conditions, kokanee
12026 would continue to provide a forage base for large predators in this system. Kokanee have
12027 increased from about 40 adult fish per acre (100 adult fish per hectare) in 2008 to about 152
12028 adults per acre (377 adults per hectare) in 2016 (Hansen et al. 2019).

12029 In the river below Albeni Falls Dam, summer water temperatures are limiting to cool and cold
12030 water fish species. Salmonid species in particular often experience lethal temperatures in this
12031 reach of river. Only brown trout, the most temperature tolerant of salmonids, survive in Box
12032 Canyon and Boundary Reservoirs, but even they are still limited in their distribution. Currently,
12033 water temperatures reach approximately 22°C in late July. Under the No Action Alternative,
12034 temperatures would continue to reach lethal levels for most cold water fish in late July.

12035 **Region B**

12036 ***Ongoing Existing Mitigation Programs***

12037 In Region B, Bonneville F&W-funded hatchery programs include programs for white sturgeon,
12038 burbot, kokanee salmon, westslope cutthroat trout, and rainbow trout. For example, the
12039 Spokane Tribe, the Confederated Tribes of the Colville Reservation, and WDFW are
12040 collaborating to implement white sturgeon monitoring and conservation aquaculture in Lake
12041 Roosevelt. Spokane Tribe, Colville Tribe, and WDFW also implement projects to support
12042 resident redband trout and kokanee. With the use of Bonneville funds, the co-managers of Lake
12043 Roosevelt (Colville Confederated Tribes, Spokane Tribe of Indians and Washington Department
12044 of Fish and Wildlife) are working to address invasive fish. For example, they have removed
12045 2,000 Northern Pike from the middle and upper sections of Lake Roosevelt since February 2018.
12046 Funding for these efforts have been provided by several other entities, including the
12047 Confederated Tribes of the Colville Reservation, Chelan Public Utility District, and Grant Public
12048 Utility District.

12049 ***Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam***

12050 Summary of Key Effects

12051 Flow, elevations, and water quality impact the quality of habitat for various resident fish species
12052 above, in, and downstream of Lake Roosevelt. For example, the Columbia River from the U.S.-
12053 Canada border would continue to support a white sturgeon population that spawns successfully
12054 but primarily relies on fish manager intervention. Sufficient flows and riverine length that allow
12055 for natural recruitment are experienced in only very few years. In Lake Roosevelt, retention
12056 time is a key metric for most fish species in Lake Roosevelt, driving the food web that supports
12057 the fish as well as influencing how many are entrained. Current levels of entrainment would
12058 continue. Lake elevations would continue to allow impaired tributary habitat access needed for
12059 spawning for redband rainbow trout and the portion of kokanee that spawn in tributaries, and
12060 reservoir operations would continue to result in some level of egg desiccation of the burbot
12061 spawn and the portion of kokanee that spawn on lake shorelines. The No Action Alternative
12062 would continue to support both wild and hatchery-raised kokanee, redband rainbow trout, and
12063 hatchery rainbow trout, as well as non-native warm water game species such as walleye,
12064 smallmouth bass, and northern pike. Under the No Action Alternative, adfluvial species are
12065 expected to continue to experience impeded migration to and from tributaries associated with
12066 varial zone effects.

12067 Northern pike would likely continue to increase and invade downstream, with that rate of
12068 invasion slowed somewhat by suppression efforts. Rufus Woods Lake would continue to
12069 provide habitat for fish entrained from Lake Roosevelt and from limited production of shoreline
12070 spawning by some species, all influenced by high TDG levels.

12071 Habitat Effects Common to This Fish Community

12072 Peak outflows typically occur in late May to mid-June during the spring freshet. Higher winter
12073 flows can happen from winter rain events or drafting for larger spring water supplies. These
12074 peak outflows can influence the rate of entrainment from Lake Roosevelt into Rufus Woods
12075 Lake. TDG concentration in the Grand Coulee tailwater is also a concern for fish in Rufus Woods
12076 Lake. Under the No Action Alternative, daily average TDG would continue to exceed the state
12077 water quality standard of 110 percent saturation from early May through mid-August, and
12078 occasionally exceed 120 percent to 125 percent saturation in some years.

12079 Retention time of water through the reservoir is a driving metric for the food web in Lake
12080 Roosevelt and influences the populations of several fish species as retention time is strongly
12081 correlated with entrainment (LeCaire 2000). Under the No Action Alternative, median retention
12082 time would range from about 40 to 50 days in the winter and early spring, dropping to as low as
12083 21 days by June, then gradually increase over the summer to about 45 days at the end of
12084 August. September and October would have high retention times, with a median of 60 to 80
12085 days. Entrainment of key species would continue, while habitat conditions would still support
12086 various life histories of these species in an impaired capacity.

12087 Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely
12088 directly on the food source provided by the zooplankton production, and higher-level predators
12089 such as bull trout prey on these fish. Zooplankton are more widespread, more plentiful, and
12090 larger in body size when retention times are higher, and tend to be smaller bodied, swept out
12091 of the reservoir faster, and more concentrated near Grand Coulee Dam with a lower retention
12092 time. In this scenario, not only is there less food available to fish, but they also tend to follow
12093 the food source and crowd down toward the dam, becoming more susceptible to entrainment.

12094 Bull Trout

12095 Bull trout are rare in Lake Roosevelt and individuals are likely occasional strays from
12096 populations in river systems north of the U.S.-Canada border isolated from their spawning
12097 habitat (USFWS 2015). Bull trout are temperature-sensitive and would continue to use this
12098 reach for foraging, migration, and overwintering habitat until temperatures reach stressful
12099 levels at about 18°C (BioAnalysts 1998). Bull trout in Lake Roosevelt, although considered rare
12100 (USFWS 2015), are believed to exhibit adfluvial behavior, overwintering in the reservoir then
12101 moving into cooler tributaries as water temperatures in the mainstem increase. The timing of
12102 temperatures reaching levels that trigger bull trout migration would be similar to that in the
12103 past. High-flow years would continue to influence bull trout distribution through flushing more
12104 of them from the river near the U.S.-Canada border down into Lake Roosevelt, similar to the
12105 high flows of 1997, after which fish managers noticed an increase in bull trout in Lake Roosevelt
12106 (unpublished data). High flows also can cause entrainment out of Lake Roosevelt and into Rufus
12107 Woods Lake, as evidenced by past surveys that have captured occasional bull trout (Lecaire
12108 2000).

12109 Bull trout prey base would continue to fluctuate, as the fish they eat are sensitive to changes in
12110 productivity and location of zooplankton in Lake Roosevelt that is influenced by how long water

12111 stays in the reservoir. Bull trout are also sensitive to contaminants that are found in this region
12112 and would continue to bioaccumulate contaminants as a top predator (See Section 3.4, *Water*
12113 *Quality*).

12114 Other Fish

12115 In the Columbia River reach from the U.S.-Canada border to Lake Roosevelt, white sturgeon are
12116 typically able to spawn, but they rarely experience successful survival from larvae to juvenile
12117 life stages, and only in extremely high-water years. Successful recruitment appears to be
12118 dependent on a combination of flows exceeding 200 kcfs and water temperatures of about
12119 14°C for 3 to 4 weeks in late June/early July (Howell and McLellan 2011 and Howell and
12120 McLellan 2014). The timing of these flows coinciding with lower reservoir levels can also
12121 increase sturgeon reproduction with the longer river habitat provided by a lower reservoir
12122 level. Other factors that would continue to influence sturgeon include: predation by fish that
12123 are favored by reservoir conditions if larvae are flushed into the Lake Roosevelt, and the uptake
12124 of contaminants such as copper closer to the U.S.-Canada border that can be flushed
12125 downstream into the reservoir by high flows. These higher flows would also continue to move
12126 larval sturgeon out of the area of higher copper concentrations. Under the No Action
12127 Alternative, recruitment of white sturgeon would continue to be a rare event supplemented by
12128 hatchery propagation, as larval sturgeon are captured and raised in hatcheries until they are
12129 past the time window where recruitment has been shown to fail at a high rate. Once these
12130 juveniles are released back into the reservoir, they continue to grow and survive well. The
12131 reservoir would continue to provide good conditions for growth and survival of these fish.

12132 Wild production of native fish such as burbot, kokanee, and redband rainbow trout would
12133 continue to provide valuable resources in Lake Roosevelt. As described in the common habitat
12134 effects, these fish are the most sensitive to the effects of changing retention times. LeCaire
12135 (2000) estimated an average of over 400,000 fish annually are entrained, 30 to 50 percent of
12136 which were kokanee, primarily of wild origin. Rainbow trout were the second most entrained
12137 species. Entrainment of key species would continue at similar rates, while habitat conditions
12138 would still support various life histories of key species in an impaired capacity.

12139 For tributary spawning species such as redband rainbow trout and a portion of the wild
12140 production of kokanee, tributary access at the right time of year is important. Reservoir
12141 drawdown in the spring creates barren tributary reaches through the varial zone, which would
12142 impede access to tributaries and the reservoir. Redband rainbow trout and the fluvial (that
12143 migrate up tributaries to spawn) portion of the kokanee population would continue to have
12144 impaired access.

12145 Species such as kokanee and burbot that spawn on shorelines are susceptible to egg desiccation
12146 if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on shoreline gravels
12147 September 15 to October 15, and eggs incubate through February. Burbot tend to spawn
12148 successfully in depths provided by the No Action Alternative in the Columbia River and in Lake
12149 Roosevelt on shorelines near the Colville River in winter, with eggs incubating through the end
12150 of March (Bonar et al. 2000). Under the No Action Alternative, reservoir elevations begin to

12151 draft from near the full pool in January, with steeper drafts starting February through April,
12152 with larger water supply forecasts requiring deeper drafts. The portion of kokanee that spawn
12153 near the fall surface elevation would be more at risk, with a lesser effect on early spawners
12154 such that the fry emerge earlier in February. Fry sometimes also stay in the gravel and could
12155 become stranded as well. Burbot spawn later in the fall so would be less affected in dry years,
12156 with only about 3 feet of reservoir drop while eggs are in gravel, but they remain in gravel until
12157 the end of March when the median reservoir elevation is more than 30 feet deeper than the
12158 fall. Burbot spawn in the Columbia River above Lake Roosevelt and in the reservoir toward the
12159 upper end. These areas would be affected as the reservoir is drafted.

12160 Kokanee are sensitive to water temperature, and during summer they are found at depths
12161 below 120 m to find suitably cool water. Under the No Action Alternative, Lake Roosevelt is
12162 very weakly stratified but does have suitably cool water at this depth along with suitable levels
12163 of DO. Lake whitefish and mountain whitefish also likely use this cool water in the summer.

12164 Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish,
12165 crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all
12166 tolerate a wide range of environmental conditions and would continue to contribute to the fish
12167 community under the No Action Alternative, and continue to adversely impact native species
12168 via predation. The invasion downstream by northern pike is of concern because they are
12169 aggressive predators that threaten native fish, including anadromous salmonids. The Lake
12170 Roosevelt Co-Managers are actively suppressing pike populations using gillnets set by boats as
12171 soon as they can get on the water in the spring until the boat ramp becomes unusable at an
12172 elevation of 1,235 feet. Under the No Action Alternative, this occurs on April 15 in wet years,
12173 and would not occur at all in dry and average years. Additionally, outflows and retention time
12174 would continue to influence the entrainment and downstream invasion of non-native gamefish
12175 below Chief Joseph Dam where ESA-listed anadromous salmonids would be susceptible to
12176 predation by them.

12177 Sterile rainbow trout are raised in net pens to provide additional recreational fishery as
12178 mitigation for the construction and operation of Grand Coulee dam. Once released, the net pen
12179 fish that supplement the rainbow trout fishery in Lake Roosevelt would experience similar
12180 effects as their native counterparts except for spawning and early rearing effects. In addition,
12181 the net pen locations are situated where the water quality can be affected by changes in
12182 reservoir elevations; these fish are sensitive to temperature and TDG, and their eventual
12183 recruitment to the fishery can be affected by retention time coupled with reservoir elevation at
12184 the time of their release (McLellan et al. 2008), which is typically in May. Under the No Action
12185 Alternative, the water quality at these locations from May 15 to June 15 would typically be
12186 suitable for rearing, with temperatures ranging from 10°C to 18°C and TDG from 101 percent to
12187 125 percent, depending on water year conditions. The upper ends of these parameters under
12188 the No Action Alternative may cause some stress to net pen fish prior to their release. The
12189 average retention time would be about 13 to 33 days during this time, and the reservoir
12190 elevation would be highly variable, depending on the water year type driving reservoir
12191 operations. The operators strive to release these fish to coincide with the initiation of reservoir

12192 refill when outflows are reduced, which under the No Action Alternative is in early to mid-May,
12193 in order to reduce the risk of newly released fish being entrained out of the reservoir. Under
12194 the No Action Alternative, this typically would result in fish being released before water quality
12195 conditions become stressful in the net pens.

12196 The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake
12197 Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter
12198 drawdown periods. This lake has more riverine characteristics with steep gradients and narrow
12199 canyon walls, making it more like a river than a reservoir, with short retention time and low
12200 productivity. High flows during late spring and early summer would continue to flush eggs and
12201 larvae from protected rearing areas. Peak outflows typically occur in late May to Mid-June
12202 during the spring freshet. TDG in the Grand Coulee tailwater is a concern for fish in Rufus
12203 Woods Lake. Under the No Action Alternative's *Spill Operations and Water Quality Plan for TDG
12204 and Water Temperature* measures, daily average TDG concentrations would continue to exceed
12205 the state water quality standard of 110 percent from early May through mid-August, and
12206 occasionally exceed 120 percent to 125 percent in some years. There are also net pens in Rufus
12207 Woods Lake, and TDG levels would continue to influence when and where these fish could be
12208 released.

12209 ***Chief Joseph to McNary Dam***

12210 Summary of Key Effects

12211 Key effects under the No Action Alternative for this reach of the Columbia River include
12212 elevated summer water temperatures; elevated TDG; hydropower dams that pose migration
12213 barriers, cause passage delays, or increase fish mortality; reductions in spawning and rearing
12214 habitats; and changes in flow patterns and temperatures that reduce spawning and recruitment
12215 success.

12216 Habitat Effects Common to All Fish

12217 Reservoirs in this reach of the Columbia River are a series of run-of-river impoundments that
12218 create slow-moving, river-like habitats. The reservoirs are mesotrophic (contain a moderate
12219 amount of dissolved nutrients) and provide ample zooplankton and aquatic invertebrates as
12220 forage for a variety of fish. This reservoir environment tends to favor non-native fish such as
12221 walleye, smallmouth bass, bluegill, perch, and crappie. Some native suckers also do well in
12222 these habitats, including bridgelip and largescale suckers. The temperatures would continue to
12223 be favorable for these cool and warmwater species. The substrate of these reservoirs is
12224 primarily silt and sand with some gravel and cobble habitats at dam tailraces. Large sections of
12225 the shoreline have been armored with riprap, providing suitable spawning habitat for many of
12226 these fish.

12227 Water quality in the reservoirs would continue to be favorable for the current fish communities,
12228 with temperatures well within the tolerance of cool and warmwater fish. High flow events in
12229 the watershed can temporarily increase the amount of suspended sediment in the reservoirs.

12230 However, under the No Action Alternative, most of the time suspended sediment levels would
12231 be less than 10 mg/L (see Section 3.4, *Water Quality*).

12232 Bull Trout

12233 Bull trout prefer water temperatures below 15°C, but adults can use temperatures up to 18 C.
12234 Although juvenile bull trout are not found in the mainstem in this river reach, temperatures
12235 above 15°C can limit their distribution (Selong et al. 2001; BioAnalysts 1998). Few bull trout are
12236 found in areas from the Chief Joseph Dam tailrace to the Okanagan River as the nearest
12237 spawning tributary is the Methow River 20 miles downstream. Adult and sub-adults exit the
12238 mainstem by early July returned to their spawning tributaries (Barrow et al. 2016; Nelson et al.
12239 2012). Under the No Action Alternative, bull trout would continue to spawn in the tributaries,
12240 and both adults and subadults would continue to use the mainstem Columbia River and
12241 reservoirs for foraging, migration, and overwintering.

12242 Effects to sub-adult and adult bull trout during passage at Mid-Columbia River dams include
12243 passage delays and mortality. Bull trout moving past Wells Dam may be delayed by about
12244 5 days and may typically experience survival rates over 95 percent (Robichaud and Gingerich
12245 2017). Under the No Action Alternative, bull trout would continue to pass all the dams in this
12246 reach except Chief Joseph and would be expected to continue to experience high survival rates.

12247 TDG levels from spill under the No Action Alternative, including through the *Spill Operations*
12248 and *Water Quality Plan for TDG and Water Temperature* measure, may adversely affect an
12249 unknown number of bull trout in the reservoirs. As discussed in Appendix D, *Water Quality*,
12250 TDG exceeds 110 percent on 11.3 percent of all days from October through July at Chief Joseph
12251 Dam and 26 percent of all days during this time at McNary Dam. Under the No Action
12252 Alternative, there continues to be a minor risk for adverse effects from TDG on bull trout May
12253 through July in this reach of the river.

12254 White Sturgeon

12255 White sturgeon spawning habitats are limited to fast water areas below run-of-river dams and
12256 the Hanford Reach. Under the No Action Alternative, an unknown number of juvenile white
12257 sturgeon would continue to be entrained from this river reach.

12258 White sturgeon generally initiate spawning in the late spring when water temperatures reach
12259 10°C to 12°C during the peak or descending limb of the hydrograph. Higher flow years have
12260 better spawning and recruitment success. Currently, white sturgeon recruitment is rare. The
12261 lack of spawning habitat and high lows to induce spawning are cited as the cause for this lack of
12262 recruitment (Hildebrand et al. 2016).

12263 Currently, an unknown number of white sturgeon succeed in passing downstream of dams on
12264 the Columbia River. Sturgeon populations in upper basins currently act as source populations
12265 for downstream recruitment. Under the No Action Alternative, these fish would continue to be
12266 limited to downstream dam passage.

12267 Elevated water temperatures can have adverse effects on white sturgeon. Temperatures over
12268 20°C can limit egg survival (Wang et al. 1985), and in some years, a combination of low flows,
12269 elevated summer temperatures, and low DO levels have led to white sturgeon mortality (IDFG
12270 2008). During 2015, elevated water temperatures interacted with large sockeye runs to
12271 increase white sturgeon mortality. Sturgeon gorged on decomposing sockeye while water
12272 temperatures were near 22°C and were unable to metabolize these fish. Under current
12273 conditions, mean high temperatures greater than 21°C would occur nearly 10 percent of the
12274 year at McNary Dam and only about 1 percent of the year at Priest Rapids Dam. Under the No
12275 Action Alternative, extreme low-flow or high-temperature years would continue to result in
12276 white sturgeon mortality events.

12277 Elevated gas or TDG can have adverse effects on white sturgeon. Larval sturgeon may
12278 experience GBT with an elevated TDG of nearly 120 percent and may have up to 50 percent
12279 mortality at a TDG of 130 percent and greater (Counihan et al. 2000). The magnitude of effects
12280 from an elevated TDG may be offset if fish are able to compensate by moving to greater depths
12281 where TDG saturation is reduced. Currently, TDG values over 118 percent occur on less than 1
12282 percent of all days in this reach of the river. Under the No Action Alternative, TDG is not
12283 expected to adversely impact white sturgeon.

12284 Other Fish

12285 Walleye require cold water over clean gravel or cobble substrates for successful spawning.
12286 Currently, water temperatures in the Columbia River are suitable for walleye spawning from
12287 early to mid-spring, and there is no shortage of suitable substrates for spawning in the mid-
12288 Columbia River reach.

12289 In addition, walleye fry require stable backwater habitats for rearing until they are able to swim
12290 proficiently. Operations that fluctuate water levels can entrain walleye fry from the safety of
12291 these critical backwater habitats. Current operations create a flow and temperature regime
12292 that would continue to support walleye growth and recruitment in these habitats on
12293 approximately 65 percent of days in the rearing period. Under the No Action Alternative,
12294 walleye would continue to have adequate spawning and rearing habitats.

12295 Smallmouth bass require stable or rising water levels and temperatures to induce successful
12296 spawning and rearing. Water temperatures between 12°C and 15°C trigger spawning activity,
12297 while stable water levels prevent the desiccation of eggs and fry. In addition, an influx of cold
12298 water, once spawning has begun, can cause males to abandon nests, resulting in recruitment
12299 failure. Current operations provide stable water levels and temperatures in most years.
12300 Modeling suggests spawning temperature of 12°C would be reached on May 3 in an average
12301 year.

12302 Cold water temperatures reduce smallmouth bass activity. In fact, when water temperatures
12303 drop below 10°C, smallmouth bass become inactive and seek shelter (Edwards 1983). If
12304 temperatures remain below this level for too long, adult fish would not survive. Currently, at
12305 McNary Reservoir, smallmouth bass would be inactive for approximately 161 days. Under the

12306 No Action Alternative, water temperatures would continue to provide adequate growth and
12307 survival for smallmouth bass populations.

12308 Smallmouth bass are visual predators, and increased turbidity can limit growth and feeding
12309 success (Sontag 2013). In addition, highly turbid waters can displace smallmouth bass fry and
12310 limit recruitment (Edwards 1983). Currently, elevated turbidity is limited to spring runoff and
12311 large rain events. The remainder of the year, water clarity is good with a suspended sediment
12312 measure of about 2 ppm. Under the No Action Alternative smallmouth bass foraging would be
12313 limited in high spring runoff and large rain events. Turbidity is not expected to limit recruitment
12314 for this alternative.

12315 Passage success for most fish at CRS projects in this reach of the Columbia River is unknown.
12316 Currently, upstream passage would be difficult for some species, while downstream passage
12317 would be associated with some unknown level of survival. Under the No Action Alternative,
12318 passage success is not expected to change. Some unknown portion of each species would
12319 continue be entrained or would pass upstream through fish ladders.

12320 Elevated summer water temperatures limit the distribution of fish species. Currently, upstream
12321 reservoirs have cooler water temperatures relative to dams lower in the reach by about 2
12322 degrees Celsius on average. This slight difference in water temperatures can affect important
12323 changes in the fish community. Under the No Action Alternative, upstream reservoirs near
12324 Chief Joseph Dam would continue to reduce growth and productivity of warmwater fish species
12325 relative to McNary Dam and the Hanford Reach.

12326 The Hanford Reach is the last remaining free-flowing reach of the Columbia River in the United
12327 States above Bonneville Dam. However, current operations above the Hanford Reach can have
12328 detrimental effects to resident fish communities. Water flows can change such that river
12329 elevations in the Hanford Reach can fluctuate by as much as 3 m in 6 hours, which has the
12330 potential to dewater aquatic habitats and reduce productivity in this reach of river. Under the
12331 No Action Alternative, the Hanford Reach would continue to be an important refuge for native
12332 resident fish species but would experience water level fluctuations that may limit productivity
12333 of this reach.

12334 **Region C**

12335 Region C consists of the Snake River Basin. Resident fish analyses in this region are discussed in
12336 one section, including the mainstem Snake River, Clearwater River, and Dworshak Reservoir.

12337 ***Ongoing Existing Mitigation Programs***

12338 In Region C, Bonneville F&W-funded projects with the Nez Perce Tribe in the Lochsa watershed
12339 are working to improve habitat for resident fish. Idaho Department of Fish and Game are also
12340 improving habitat for Yellowstone cutthroat trout. Riparian, wetland, and instream habitat
12341 restoration in Region C that targets anadromous fish or wildlife species also can improve
12342 habitat conditions for resident fish species. Through its F&W Program, Bonneville funds many

12343 habitat restoration actions that benefit multiple species. For example, the Shoshone-Bannock
12344 Tribes of the Fort Hall Reservation have enhanced over five miles of the Yankee Fork Salmon
12345 River to promote anadromous and resident fish habitat.

12346 Another example is the Dworshak Dam Resident Fish Mitigation, which boosts Kokanee Salmon
12347 abundance, thereby providing forage resources (eggs, fry, sub-adults) for bull trout, cutthroat
12348 trout, and other resident fish species in the blocked area of the North Fork Clearwater River.

12349 ***Snake River Basin***

12350 Summary of Key Effects

12351 Kokanee would continue to use Dworshak Reservoir during most of their life history and return
12352 to the tributaries to spawn. Reservoir elevations in the fall would provide access to about 90
12353 percent of their spawning areas. The chance of kokanee being entrained through the dam
12354 would be low, with the highest risk in late February and all of March. Dworshak Reservoir would
12355 also continue to provide habitat for smallmouth bass.

12356 Under the No Action Alternative, the Snake River Dams would continue to fragment white
12357 sturgeon habitat by limiting passage upstream and downstream. Populations of white sturgeon
12358 in the Ice Harbor, Lower Monumental, and Little Goose Reservoirs would be expected to
12359 continue to decline from lack of recruitment (young fish surviving past the larval stage and up
12360 to 1 year of age). Habitat conditions for white sturgeon would continue to be of limited
12361 adequacy in the reservoirs under the No Action Alternative. Water temperature would be
12362 within the range needed for spawning and rearing. Flows and substrate in the tailraces of the
12363 four Snake River Dams would provide suitable habitat for spawning and rearing. Water quality
12364 would be sufficient to support white sturgeon.

12365 The No Action Alternative would continue to provide reservoir conditions that favor non-native
12366 fish such as walleye and smallmouth bass. No change in resident fish populations or their use of
12367 the Snake River Basin would be expected, except for walleye. Walleye have been expanding
12368 their range upriver in the reservoirs and are now found as far upstream as Little Goose
12369 reservoir. Two crustaceans, Siberian prawns and opossum shrimp, are increasing their
12370 populations in the lower Snake River Reservoirs and may provide an additional food source for
12371 resident fish. This population trend may continue under the No Action Alternative.

12372 Habitat Effects Common to this Fish Community

12373 The Snake River Reservoirs are a series of run-of-river impoundments that create a long run of
12374 reservoir and slow-moving river habitat. This reservoir environment tends to favor non-native
12375 fish such as northern pikeminnow, walleye, smallmouth bass, bluegill, perch, and crappie. Some
12376 native suckers also do well in these habitats, including bridgelip and largescale suckers.
12377 Generally, the temperatures would continue to be favorable for these warmwater species to be
12378 abundant and some may increase in population and distribution. Much of the substrate in the

12379 reservoirs is sand or cobble, and large amounts of shoreline have been armored with riprap,
12380 providing suitable spawning habitat for these fish.

12381 Water quality in the reservoirs would continue to be favorable, with temperatures well within
12382 the tolerance of warmwater fish, and consistently favorable levels of DO. High-flow events in
12383 the watershed can temporarily increase the amount of suspended sediment in the reservoirs.
12384 However, under the No Action Alternative, most of the time, suspended sediment levels would
12385 be less than 10 mg/L (Appendix D).

12386 Bull Trout

12387 Under the No Action Alternative, low numbers of bull trout would continue to use the
12388 mainstem of the Snake River for foraging, migration, and overwintering and some movement
12389 between populations would continue. Bull trout migrate foraging, migration, and overwintering
12390 habitat in November and December, then return to tributaries in March through May. Lower
12391 Monumental and Ice Harbor Reservoirs provide a connection between the Tucannon and Walla
12392 Walla Subbasins, with some Tucannon fish moving downstream through the Snake River to the
12393 Columbia River, then up the Walla Walla River. Larger bull trout that do use the Snake River are
12394 the drivers of the population as they are generally more productive. Potentially, the loss of the
12395 larger, fluvial fish (fish that spawn and rear in tributaries, then migrate to a lake) from the
12396 upstream community could drive a change in that community structure.

12397 Bull trout movement through the basin would continue to be primarily downstream rather than
12398 upstream under the No Action Alternative. Low numbers of fish would continue to be entrained
12399 at the Snake River Dams and passed downstream either through the turbines or through the
12400 juvenile salmon bypass systems. This movement at the dams is primarily between April and
12401 June when the fish are moving out of the reservoir system to avoid higher water temperatures.
12402 Even though the fish ladders at the dams were not designed to pass bull trout (Barrows et al.
12403 2016), low numbers of bull trout would be expected to continue to use the fish ladders to move
12404 upstream to other reservoirs and the upper basin. Bull trout movement through the fish
12405 ladders on the lower Snake River Dams would continue to be temporarily halted when the
12406 ladders are closed for maintenance in January and/or February.

12407 Under the No Action Alternative, migration of bull trout to the North Fork Clearwater River
12408 Subbasin from the rest of the Clearwater Basin would continue to be blocked by Dworshak Dam,
12409 as the dam has no fish ladders or other means of passing fish upstream. However, bull trout in
12410 Dworshak reservoir would continue to have access to most spawning areas in tributaries above
12411 the dam. The reservoir drawdown does not eliminate the ability of fish to access the free-flowing
12412 reach of the North Fork Clearwater above the reservoir. The timing of reservoir refill coincides
12413 with the time in May and June that adult bull trout begin their upstream migration (Hanson et al.
12414 2006) and would continue to provide connectivity between the reservoir, tributaries, and the
12415 rest of the North Fork Clearwater Basin under the No Action Alternative.

12416 Water temperature would remain cold enough for low numbers of bull trout to continue to use
12417 the Snake River Reservoirs and the Snake and Clearwater Rivers during much of the time they
12418 are most likely to be present, primarily November through May (Barrows et al. 2016). Under

12419 the No Action Alternative, the water quality modeling shows water temperatures in the lower
12420 Snake Reservoirs are expected to exceed 15°C 0.3 percent of the time from November through
12421 May, resulting in a negligible effect on bull trout.

12422 Elevated TDG levels from spill may adversely affect an unknown number of bull trout in the
12423 reservoirs by degrading habitat in the mainstem Snake River and causing habitat loss. Bull trout
12424 effects from an elevated TDG during spill was determined using the number of days that TDG
12425 would be over 110 percent between November and June, the months bull trout are most likely
12426 to be in the Snake River reservoirs. Under the No Action Alternative, 37.3 percent of days
12427 November through June would exceed 110 percent TDG through the *Spill Operations* measure.
12428 Suspended sediment and DO would continue to be within tolerance levels for bull trout.

12429 Forage for migrating bull trout in the Snake River would continue to be adequate in the lower
12430 Snake River under the No Action Alternative. The Snake/Clearwater River system supports
12431 healthy populations of forage fish.

12432 The potential for predation on bull trout in the rivers and reservoirs would also be reduced
12433 under the No Action Alternative because bull trout use these areas in the winter when the
12434 water is generally cold. Warmer water temperatures generally are associated with higher risk of
12435 predation. Predators such as catfish, northern pikeminnow, walleye, and smallmouth bass are
12436 more active when water temperatures are relatively warm (greater than 15°C).

12437 White Sturgeon

12438 Spawning behavior by white sturgeon in the Snake River Basin is not expected to change under
12439 the No Action Alternative. Spawning behavior is cued by high water velocities during the period
12440 just after peak runoff and by adequate temperatures (Hildebrand et al. 2016). Spawning is
12441 currently limited in most areas of the Snake River Reservoirs because water velocities are not
12442 adequate to cue spawning. However, some spawning occurs near the dams in the tailraces
12443 where velocities are higher. The mean water velocity to support spawning needs to be greater
12444 than or equal to 2.6 feet/second, but the average velocity for the year under the No Action
12445 Alternative would be about 0.4 feet/second.

12446 Water temperatures in the lower Snake River would be suitable for sturgeon spawning under
12447 the No Action Alternative. Spawning in the Snake River occurs between April and July and when
12448 water temperatures are between 12°C and 18°C (Hildebrand et al. 2016). Modeling results for
12449 the April 15 and June 30 spawning period under the No Action Alternative indicate water
12450 temperatures would be above 18°C for 8.2 percent of the time. This indicates water
12451 temperatures would be within the acceptable range for most of the spawning period.

12452 Water temperatures in the lower Snake River would also be suitable for egg incubation under
12453 the No Action Alternative. Water temperature is critical for white sturgeon egg incubation.
12454 Temperatures outside of the 8°C to 18°C range show reduced egg survival, with mortality
12455 occurring when temperatures are greater than 20°C (Lepla and Chandler 2001). Modeling
12456 results for the spawning period between April 15 and June 30 indicated water temperatures
12457 would be below 8°C for 0.3 percent of time, and above 18°C for 8.2 percent of the time).

12458 Modeling results also showed water temperatures above 20°C for 2.7 percent (168 out of 6,160
12459 days) during the spawning period. This indicates water temperatures would be within the
12460 acceptable range for egg incubation during the spawning period.

12461 The Snake River would continue to provide limited rearing habitat for the yolk sac larvae under
12462 the No Action Alternative. The preferred habitat for these larvae is gravel and cobble substrates
12463 with interstitial spaces in which to hide (Hildebrand et al. 2016; McAdam 2012). This type of
12464 substrate is limited in most areas of the reservoirs. However, previous surveys of the Snake
12465 River Reservoir substrate have shown that gravel and cobble habitat occurs primarily in the
12466 tailraces of each of the Snake River Dams. These tailrace areas would continue to provide
12467 potential habitat for the yolk sac larvae under the No Action Alternative.

12468 Snake River Reservoir trophic production would continue to provide adequate forage for larval
12469 (less than 1 year of age), juvenile (1 to 7 years of age), and adult white sturgeon under the No
12470 Action Alternative. All of food organisms for each life stage are found in adequate quantities in
12471 the reservoirs and would not limit the sturgeon population. The increasing number of Siberian
12472 prawns and opossum shrimp in the reservoirs would provide an additional food source for
12473 sturgeon.

12474 Migration of white sturgeon through the lower Snake River would continue to be hindered by
12475 the dams due to the limited to no passage at the dams (though a few have been observed
12476 moving downstream). Sturgeon do move between Lower Granite Reservoir and the free-
12477 flowing section of the river above the reservoir. There appears to be a gradient of reduced
12478 abundance of juvenile sturgeon with increased distance from Lower Granite Dam. This suggests
12479 that many of the white sturgeon in the lower Snake Reservoirs could have been entrained
12480 through the dams (Hildebrand 2016; Devore 1999). It is also possible that juvenile sturgeon
12481 move downstream seeking food sources.

12482 Under the No Action Alternative with its *Spill Operations* measure, TDG levels at the dams
12483 would have an adverse effect on white sturgeon for about 10 days, primarily in June and July.
12484 Young white sturgeon are sensitive to TDG levels (McGrath 2006; Weitkamp 2008; Hildebrand
12485 2016; Counihan et al. 1998). TDG levels of 118 percent alters buoyancy in larval white sturgeon,
12486 which make them more prone to predation. TDG levels of 130 percent cause about 50 percent
12487 mortality. Modeling shows that under the No Action Alternative, TDG levels would be greater
12488 than 120 percent for 809 of 9,760 days from April 1 through July 31, or 8.3 percent of that
12489 period, with a high of 136 percent TDG. Suspended sediment and DO levels would remain
12490 favorable for sturgeon.

12491 In-river contaminants are not likely to affect white sturgeon populations under the No Action
12492 Alternative. Sturgeon are highly sensitive to in-river contaminants such as selenium and
12493 methylmercury, which can have sublethal effects (Coffey 2014; Little 2014; Wan Ming 2014).
12494 Through the portion of the Snake River downstream of the confluence of the Snake and
12495 Clearwater Rivers, these contaminants are not expected to be found in the sediments in
12496 concentrations that would affect sturgeon.

12497 Predation and harvest would have little effect on white sturgeon under the No Action
12498 Alternative. There are no known adult predators of sturgeon in this subbasin (several fish
12499 species prey on sturgeon eggs and juveniles, including walleye, smallmouth bass, and sculpin).
12500 Harvest is not allowed on the lower Snake River except below Ice Harbor Dam, but catch-and-
12501 release recreational fishing on sturgeon is allowed. The estimated mortality of this fishing is
12502 about 3 percent, which may have a minor effect on white sturgeon populations (Robichaud et
12503 al. 2006).

12504 Other Fish

12505 Dworshak Reservoir and the Clearwater are inhabited predominantly by cold water species
12506 such as kokanee bull trout, westslope cutthroat trout, redband rainbow trout, as well as the
12507 cool-water-favoring smallmouth bass. Westslope cutthroat occur in Dworshak Reservoir and
12508 the Clearwater Basin, but would not likely be affected by the MOs. They are not addressed
12509 further.

12510 Redband rainbow trout are divided into two subgroups. Trout that are anadromous are
12511 considered to be steelhead. Those that are residents of the interior Pacific Northwest are
12512 redband or resident rainbow trout (Muhlfeld et al. 2015). Within the Snake River Basin,
12513 redband rainbow trout that interact with the projects are classified as steelhead and are
12514 addressed in the four steelhead sections (Upper Columbia River, Snake River, middle Columbia
12515 River, and Lower Columbia River steelhead), under Anadromous Fish, under Section 3.5.2.2, No
12516 Action Alternative. Those redband rainbow trout that are in the tributaries are not likely to be
12517 affected by actions at the projects and are not addressed further.

12518 In the Snake River Subbasin reservoirs, kokanee are found only in Dworshak Reservoir, where
12519 they were introduced in 1972. Since their introduction, kokanee have become the primary
12520 fishery in the reservoir. Kokanee spawning normally occurs in the fall and would continue along
12521 the tributaries to Dworshak reservoir under the No Action Alternative. Spawning areas are
12522 inaccessible when the reservoir level is below elevation 1,450 feet during September and
12523 October. However, under the No Action Alternative the mean water elevation in the reservoir
12524 in September and October would be at elevation 1,521, therefore kokanee would have access
12525 to about 90 percent of their spawning areas in most years.

12526 Entrainment of kokanee at Dworshak Dam would continue to be of concern under the No
12527 Action Alternative if the Corps needs to release large volumes of water in the winter or spring.
12528 Entrainment occurs when water is released from the dam and fish in the forebay are pulled
12529 through the dam along with the water. Entrainment at Dworshak Dam is mostly a problem in
12530 the winter when kokanee congregate near the dam, making them susceptible to high discharge,
12531 as opposed to other times of the year when they are using the upper parts of the reservoir near
12532 the spawning areas. Kokanee entrainment is positively related to discharge during January
12533 through March (Bennett 1996). However, the use of lower gates to release water away from
12534 kokanee populations has likely reduced the effect. Historically, the Corps has released water in
12535 the fall and winter to make room for flood storage. Large numbers of kokanee have been
12536 removed from the reservoir during high winter releases, which can result in lower populations

12537 that can take several years to rebuild. Entrainment has been reduced in recent years now that
12538 the Corps starts releasing water in the summer for flow augmentation and cooling of the lower
12539 Snake River and does not wait until winter to start to release water (personal communication,
12540 Paul Pence, April 29, 2019). Modeling results for the No Action Alternative show median
12541 discharges from Dworshak would remain low for January through March, with a maximum flow
12542 typically near powerhouse capacity. The highest risk would be in late February and the entire
12543 month of March. High water years have a greater risk of entrainment. Median years have risk in
12544 late March.

12545 Smallmouth bass also inhabit Dworshak Reservoir. Dworshak Reservoir provides smallmouth
12546 bass spawning habitat along the shoreline, but the timing of the reservoir operations could
12547 interrupt the spawning/rearing cycle under the No Action Alternative. Smallmouth bass spawn
12548 in the spring (Webster 1954, as cited in Wile 2014). Males move into spawning areas when the
12549 water temperature reaches about 16°C (Wile 2014). The optimum temperature range for
12550 spawning is 12.8°C to 21°C (Edwards et al. 1983). Dworshak reservoir start to refill in April or
12551 early May, usually reaching full pool elevation of 1,600 feet by July 4. After July 4, water
12552 releases from the reservoir for flow augmentation and cooling water lower the reservoir to
12553 elevation 1,520 by September. Water temperatures under the No Action Alternative would not
12554 reach 16°C, the temperature at which smallmouth bass spawn, until about May 7. In most
12555 years, smallmouth bass would be able to spawn, and the fry should be able to leave the nesting
12556 area before the drawdown would desiccate the nest. In Dworshak reservoir, smallmouth bass
12557 feed on several fish species, including kokanee. The abundance of kokanee contributes to the
12558 growth of smallmouth bass in the reservoir (IDFG 2018).

12559 In the lower Snake River Reservoirs and river reaches, several non-native fish would continue to
12560 dominate the resident fish community. Native mountain whitefish would continue to be found
12561 in the tributaries. Downstream passage past the dams would be possible. The Corps has found
12562 mountain whitefish in the juvenile bypass system in varying numbers at Lower Monumental
12563 Dam. The Corps recorded 521 fish in the bypass in 2017 and 235 fish in 2018.

12564 Northern pikeminnow prefer slow-moving water in lakes and rivers with gravel or soft sand
12565 substrates (Gadomski et al. 2001), that would continue to be provided by the lower Snake
12566 River. Northern pikeminnow prefer temperatures of 16-22°C but are found in warmer waters
12567 (Brown and Moyle 1981). Temperature modeling for the No Action Alternative predicted that
12568 water temperatures in the tailrace of Ice Harbor Dam would reach 14°C around June 5 and
12569 would be above 15°C for 88.7 percent of the modeled days (10,826 days) from June through
12570 October. Therefore, water temperatures would continue to support successful spawning and
12571 rearing by Northern pikeminnow. No Action Alternative conditions would continue to provide
12572 adequate food sources for larval and juvenile Northern pikeminnow. Because Northern
12573 pikeminnow rear in the gravels in the tailraces of the dams where the water is shallower and
12574 the TDG levels are higher, there is the potential for the juveniles to be adversely affected.
12575 Water quality modeling indicated TDG levels would be above 120 percent for 809 out of 9,760
12576 modeled days (8.3 percent of the time) in April through July at Ice Harbor with a high of 136
12577 percent TDG. The water quality plots show the majority of the days would be in June and July.

12578 Under the No Action Alternative and its *Spill Operations* measure, elevated TDG would have an
12579 elevated adverse effect on northern pikeminnow for about 10 days, primarily in June and July.
12580 Occasional high-flow sediment events may occasionally affect northern pikeminnow, but most
12581 of the time would be low. DO and suspended sediment would be within tolerances for northern
12582 pikeminnow.

12583 Walleye are abundant in Ice Harbor and Lower Monumental Reservoirs and are increasingly
12584 found in Little Goose reservoir. Adults have been found in Lower Granite Reservoir. Under the
12585 No Action Alternative, the reservoirs would continue to provide adequate spawning habitat and
12586 forage that would support large numbers of walleye. The lower Snake River Reservoirs would
12587 also continue to provide adequate conditions for walleye spawning. Temperature modeling for
12588 the No Action Alternative shows that water temperatures in the lower Snake River Reservoirs
12589 would be suitable for walleye spawning from mid-February to mid-April, which is within the
12590 period when walleye spawn. The lower Snake River Reservoirs would continue to provide
12591 adequate water temperature conditions for rearing walleye fry under the No Action Alternative
12592 for at least part of the year. Water temperatures would be too cold for optimum growth of fry
12593 when they first hatch, but conditions would improve and best growth would occur after mid-
12594 June. High or variable water velocities in rearing areas during April and May can transport
12595 juveniles to unsuitable habitats (reference to be added prior to final). Modeling for the No
12596 Action Alternative shows median flows in the lower Snake River during this time would be
12597 relatively high. Successful rearing would occur at limited sites with adequate shelter from high
12598 flows. Adequate resting and feeding habitat for adult walleye is currently provided by the lower
12599 Snake River reservoirs. Adults prefer deeper water offshore habitat during daylight hours, then
12600 move into shallow water feeding sites along the shoreline at night (reference to be added prior
12601 to final). These types of habitat are not limited in the lower Snake River and would continue to
12602 be available under the No Action Alternative.

12603 Smallmouth bass would also continue to flourish. Much of the substrate in the reservoirs is
12604 sand or cobble, and large amounts of shoreline have been armored with riprap (large rock),
12605 which would continue to provide cover for nests. Water temperatures in the lower Snake River
12606 would continue to be conducive for embryo development under the No Action Alternative.
12607 Smallmouth bass prefer temperatures ranging from 12 to 31°C (Ferguson 1958; Barans and
12608 Tubb 1973; Reutter and Herdendorf 1974), and lower temperatures would be less favorable for
12609 smallmouth bass. Water flows and temperatures would be suitable for smallmouth bass fry in
12610 the lower Snake River in mid to late summer under the No Action Alternative. Conditions would
12611 be best for fry in July and August as there would be low flows and relatively high water
12612 temperatures. Temperatures in the lower Snake River, as represented by Little Goose Reservoir,
12613 would exceed 21°C, and thereby provide ideal growth conditions, for only about 52 days per
12614 year (14.3 percent of all days). However, the high numbers of smallmouth bass in the reservoirs
12615 show this is not currently limiting the population. Smallmouth bass growth would continue to
12616 increase in May to June. Water temperatures in the lower Snake River Reservoirs would affect
12617 the activity level of adult smallmouth bass under the No Action Alternative. Under the No
12618 Action Alternative, water temperatures in the lower Snake River Reservoirs, as represented by
12619 Little Goose Reservoir, would reach 10°C starting about April 25 and stay above that

12620 temperature until about November 12. Temperatures would be below 10°C for about 168 days
12621 out of the year, or 46.0 percent of the year. This would result in adults being inactive during the
12622 late fall through early spring, and then becoming active starting in May.

12623 DO, turbidity, and suspended sediment levels in the lower Snake River under the No Action
12624 Alternative would be within acceptable limits for smallmouth bass growth and survival most of
12625 the time. High turbidity can limit growth and feeding success of adult smallmouth bass as they
12626 are sight feeders and turbidity can limit their ability to locate prey. Sontag (2013) found a drop
12627 in smallmouth bass predation during flows with high turbidity. Turbidity in the lower Snake
12628 River is usually less than five Nephelometric Turbidity Units and rarely exceeds 200
12629 Nephelometric Turbidity Units but could limit feeding success of smallmouth bass during early
12630 runoff in some years under the No Action Alternative.

12631 **Region D**

12632 ***Ongoing Existing Mitigation Programs***

12633 Bonneville's F&W Program in Region D includes projects that focus on bull trout and sturgeon.
12634 Bonneville has worked with the Confederated Tribes of the Warm Springs to monitor the status
12635 of bull trout in the Lower Deschutes basin. ODFW, WDFW, and CRITFC have been conducting
12636 long-term monitoring of white sturgeon populations on the Lower Columbia. Floodplain,
12637 wetland, and instream habitat improvement that targets anadromous fish or wildlife also
12638 improves habitat conditions for resident fish species.

12639 ***McNary Dam to the Columbia River Estuary***

12640 Summary of Key Effects

12641 Bull trout would continue to migrate upstream and downstream through the Columbia River
12642 System in limited numbers and seek thermal refugia (i.e., cold water habitat) available at the
12643 mouths of tributaries. White sturgeon would continue to successfully reproduce in years with
12644 adequate flow and temperature conditions.

12645 Habitat Effects Common to this Fish Community

12646 Outflows from McNary Dam Reservoir would influence some of the fish relationships described
12647 in this section. Peak spring flows affect habitat maintenance for some species. Modeled mean
12648 monthly outflows for the No Action Alternative are as follows:

- 12649 • April: 191,600 cfs
- 12650 • May: 260,300 cfs
- 12651 • June: 285,020 cfs
- 12652 • July: 197,900 cfs

12653 Other flow parameters referred to in this section refer to outflows of McNary Dam that are
12654 indicative of flows downstream through the other projects.

12655 Bull Trout

12656 Bull trout are known to use the mainstem Columbia River to move between tributaries and
12657 have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et
12658 al. 2016). Water temperature is the most important habitat factor for bull trout in the
12659 mainstem Columbia River. Fluctuations in the Bonneville Dam pool could suppress vegetation
12660 on the delta at the mouth of the Klickitat and Hood Rivers, making bull trout more susceptible
12661 to predation when trying to access tributaries or use the mouth of the tributary for thermal
12662 refugia (personal communication, Bill Sharpe, Yakama Nation, 2019). Under the No Action
12663 Alternative, bull trout would continue to use the mainstem Columbia for migration between
12664 tributaries, as well as tributary mouths for passage and thermal refugia.

12665 Adult bull trout move downstream during fall and overwinter in reservoirs (October to
12666 February; Barrows et al. 2016). Although bull trout successfully move between areas on the
12667 mainstem, their migration can be delayed at the dams. Passage through turbines can cause
12668 injury or mortality.

12669 Bull trout are subject to bird predation, as evidenced by recovery of PIT tags on bird colonies
12670 (Barrows et al. 2015). Predation on bull trout would continue to occur under the No Action
12671 Alternative.

12672 White Sturgeon

12673 White sturgeon occur throughout the lower Columbia River from McNary Dam to the estuary,
12674 but abundance is highest below Bonneville Dam and decreases further upstream (ODFW 2019).
12675 Factors important for white sturgeon relative to the operations of the CRS include flow rates,
12676 water quality (temperature and TDG), predation, and habitat conditions. To compare habitat
12677 characteristics important for white sturgeon to the MOs, the modeled median monthly
12678 outflows and modeled temperatures at Bonneville Dam (based on the period of record) were
12679 examined for the relevant time periods and documented. The Bonneville Dam tailrace was used
12680 as an indicator, because the highest abundance numbers for white sturgeon occur from
12681 Bonneville Reservoir downstream to the estuary. Under the No Action Alternative, the
12682 Bonneville Dam tailrace would provide suitable spawning and incubation temperatures from
12683 mid-April to mid-July. Model results indicate suitable spawning temperatures occurring from a
12684 range of 48 days (2015) to 74 days (2012). The number of days with optimal embryo incubation
12685 (12°C to 14°C) would range from 8 days (2013) to 27 days (2011). In years of low-flow
12686 conditions, water temperatures could increase beyond the suitable range by early June,
12687 resulting in little or no recruitment.

12688 Flows for successful sturgeon spawning and recruitment were analyzed based on the McNary
12689 Dam tailrace. Since lower Columbia River Dams are run-of-river, the outflow at McNary Dam
12690 correlates with the outflows at John Day, The Dalles, and Bonneville Dams. Flows of at least 250

12691 kcfs from April 1 to July 31, coupled with suitable temperatures, provide favorable spawning
12692 and rearing conditions. Flows would continue to be adequate for sturgeon spawning and
12693 recruitment in most of the April to June timeframe in high-flow years, but only about half of the
12694 time in average flow conditions. Low-flow years would likely not provide sufficient time with
12695 suitable flows for recruitment to occur. In years of extreme low flows and warm water, higher-
12696 than-typical adult mortalities have been documented (personal communication, O. Langness
12697 2019).

12698 White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse
12699 substrates (Parsley et al. 1993). McCabe and Tracy (1994) concluded that spawning in the
12700 Bonneville Dam tailrace occurred on days with mean discharges from Bonneville Dam, ranging
12701 from 120 kcfs to 371 kcfs. Model results for the current analysis indicate that flows are always
12702 higher than 120 kcfs from April through July.

12703 Lack of effective upstream white sturgeon passage for all age classes decreases the connectivity
12704 of the population (Parsley et al. 2007). Under the No Action Alternative, disconnection in
12705 populations would continue. White sturgeon are known to pass through the dams, although
12706 this only occurs in the downstream direction (Warren and Beckman 1989). The spillway is the
12707 most likely source of downstream passage.

12708 Turbine units at Bonneville Dam can cause injury and mortality in juvenile and adult sturgeon
12709 due to blade strikes. This has been reduced by the slow-roll procedure for starting up turbines.
12710 Under the No Action Alternative, a small amount of injuries or mortalities could occur, but the
12711 incidence would be greatly reduced by continuing to implement the slow-roll start-up
12712 procedure.

12713 White sturgeon larvae are adversely affected by TDG. Studies have shown high rates of altered
12714 buoyancy at 118 percent TDG, and 50 percent mortality at 131 percent TDG (Counihan et al.
12715 1998).

12716 Changes in a pool or tailrace elevation can affect juvenile white sturgeon through stranding in
12717 shallow water. Under the No Action Alternative, pool elevations in the reservoirs would remain
12718 consistent.

12719 Pinnipeds, mainly Steller sea lions, are known to prey on white sturgeon in the Bonneville Dam
12720 tailrace. Stellar sea lions have increased their abundance and seasonal presence (Tidwell et al.
12721 2019). Pinnipeds may have altered the spawning of white sturgeon in the Bonneville Dam
12722 tailrace as they attempt to avoid predation. ODFW has observed direct predation on sturgeon
12723 and harassment of spawning sturgeon by Steller sea lions, which can lead to stress and aborted
12724 spawning activity (personal communication, Chapman 2019). Resident fish such as sculpin,
12725 walleye, and smallmouth bass are predators of embryo and age-0 white sturgeon. Under the No
12726 Action Alternative, predation would continue to affect early life stages of white sturgeon.

12727 Reservoirs in the lower Columbia have higher rates of sedimentation, and invasive aquatic
12728 plants could reduce habitat value for sturgeon through changes in predation, food availability,

12729 and suitability for invasive species. This trend would be expected to continue under the No
12730 Action Alternative.

12731 Other Fish

12732 Within this reach of the lower to middle Columbia River, at least 45 resident fish species occur,
12733 of which over half are native (NPPC 2001; Ward et al. 2001). In addition to white sturgeon and
12734 bull trout (discussed previously), Northern pikeminnow, walleye, smallmouth bass, native
12735 minnow species, and estuarine fish assemblages occur within this reach. Walleye, smallmouth
12736 bass, and other non-native gamefish are warmwater fish species, and channel catfish are
12737 present in the lower CRS.

12738 Habitat components important for these resident fish communities include flow rates, water
12739 quality, and food availability. The mainstem dams are barriers to upstream movements by most
12740 resident fish. However, resident fish are known to pass through fishways at the dams. TDG
12741 levels could have adverse effects on any of the resident fish species. ODFW sampling during
12742 spring, when higher TDG rates occur, did not observe GBT in pikeminnow, smallmouth bass, or
12743 walleye.

12744 Northern pikeminnow are a part of the resident fish community and are important in their role
12745 as predators of salmon and steelhead. Analysis of pikeminnow considered their life history and
12746 the potential for MOs to affect their predation rates. Northern pikeminnow have a plasticity to
12747 adapt to different environs, and there are different life histories between the free-flowing and
12748 impounded river sections. Pikeminnow abundance in the lower Columbia is highest from the
12749 estuary to The Dalles, with lower abundance further upstream. Spawning occurs in June
12750 through July when temperatures are above 18°C, over clean, rocky substrate in a range of
12751 depths (Lower Columbia River Province Plan 2004 to 2005 NWPCC). In reservoir areas, high
12752 flows followed by low flows could affect recruitment. Because they spawn at multiple depths,
12753 they are less sensitive to potential dewatering. Some tributaries have viable populations that
12754 seed downstream reservoirs with juveniles, so pool fluctuations are unlikely to have
12755 population-level effects. Survival of rearing juveniles appears highest in low flow years when
12756 shoreline water temperatures are higher (20°C) and there is abundant vegetation. Northern
12757 pikeminnow are site feeders and may decrease their feeding effectiveness during higher
12758 turbidity. Northern pikeminnow would be expected to maintain their current abundance levels
12759 under the No Action Alternative.

12760 The adult optimum temperature for walleye is 20°C to 24°C, and growth stops below 12°C.
12761 Smallmouth bass have similar spawning timeframes and temperatures (mid-May to late June,
12762 when water temperatures reach 15.6°C to 18.3°C.) Female walleye gonad maturation requires
12763 winter temperatures less than 10°C, and optimum temperatures are 6°C to 9°C. When spring
12764 temperatures increase slowly (less than 0.18 degree Celsius per day), there is poor embryo
12765 survival. As the lower Columbia River system reservoirs operate as run-of-the-river, operations
12766 are unlikely to affect these conditions. Conditions that slow fry growth (low temperatures, low
12767 zooplankton abundance, and delayed hatching), increase overwinter mortality, because smaller
12768 fish tend to have lower survival rates. Under the No Action Alternative, food abundance is

12769 supportive of walleye growth rates. The John Day Reservoir has smaller walleye, which may be
12770 an effect of harvest (no angling limits on walleye, and harvest of larger fish leaves a population
12771 of smaller individuals). Smallmouth bass juveniles are affected more by discharge than by
12772 temperature during nursery season, because fry can be displaced from nests during high flow
12773 velocity (Larimore 2000; Simonson and Swenson 1990, as cited in Brown et al. 2009.)
12774 Smallmouth bass make and tend nests until hatching, and if a nest is disturbed or depth
12775 increases beyond 4 feet, they abandon the nest; this could be affected by reservoir pool
12776 elevations.

12777 Smallmouth bass experience a winter starvation period when temperatures are below 7°C to
12778 10°C (Shuter et al. 1980; Henderson and Foster 1956, as cited in Brown et al. 1990) Juveniles
12779 must grow enough during their first year to survive the winter period, and juvenile shad provide
12780 an important fall forage source for growth going into winter.

12781 Similar to Northern pikeminnow, pool elevations dropping after Walleye spawning under the
12782 No Action Alternative can strand eggs or larvae, but this is not expected to cause population-
12783 level effects. The reservoirs have generally reduced variability in seasonal and daily flows.
12784 Newly hatched fry require food (plankton) at 3 days after hatching; fry are surface oriented and
12785 need low velocities. This life stage is population-limiting below Bonneville Dam (Lower
12786 Columbia River Province Plan 2004 to 2005 NWPCC). Higher velocities during the timeframe
12787 when fry are emerging could be a method to limit production.

12788 Smallmouth bass shift to fish prey during their first year, due to caloric intake and growth needs
12789 (Brown et al. 2009). Their diet consists of sculpin, cyprinids, suckers, and sand rollers. Juvenile
12790 salmon are eaten during their migration (at sizes of less than 100 mm).

12791 Conditions that promote lower water temperatures and higher spring flows tend to lower the
12792 survival rates of warmwater game fish, potentially lowering populations of salmon and
12793 steelhead predators. The No Action Alternative would be expected to continue supporting
12794 warmwater game fish at levels similar to current conditions.

12795 **MACROINVERTEBRATES**

12796 Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under the No Action
12797 Alternative. For more detailed information on the effects of the No Action Alternative on
12798 aquatic invertebrates and implications on food web interactions, see the Habitat Effects
12799 sections of these respective fish community analyses in the Resident Fish section under the
12800 applicable region.

12801 **Region A**

12802 Aquatic invertebrate communities would continue to thrive in the aquatic environments
12803 provided by Hungry Horse Reservoir, South Fork Flathead River, Flathead River, Flathead Lake,
12804 lower Flathead River, Clark Fork River, Lake Pend Oreille, Pend Oreille River, Lake Koocanusa,
12805 and the Kootenai River.

12806 The storage reservoirs (Hungry Horse, Lake Pend Oreille, and Lake Koocanusa) in Region A
12807 typically have low nutrients and good water quality. Reservoir elevations in the summer would
12808 continue to provide a large area for production of phytoplankton and zooplankton, with No
12809 Action Alternative operations typically filling to or nearly to full pool in most years and dropping
12810 relatively slowly through the summer. Outflows of these reservoirs would continue to carry a
12811 proportion of the zooplankton out of the reservoirs and into the rivers downstream. The varial
12812 zones of reservoirs would continue to provide habitat for production of benthic aquatic insects
12813 when inundated, and this benthic production would continue to be constrained by fluctuations
12814 in surface elevations. Larger, long-lived species would continue to dominate in the permanently
12815 wetted zones of the reservoir, and shorter-lived, smaller species would colonize the varial zone
12816 that is only inundated part of the year. These bottom-oriented aquatic insect life stages would
12817 continue to provide an important spring food source for fish. Flathead Lake and Lake Pend
12818 Oreille would also continue to support expanding populations of opossum shrimp. These
12819 shrimp would continue to compete with kokanee as both rely on zooplankton for food, but they
12820 also provide food sources for other species such as lake trout.

12821 The riverine sections of Region A such as the Flathead River, Clark Fork River, Pend Oreille River,
12822 and Kootenai River would continue to produce benthic macroinvertebrates such as the larvae
12823 of stoneflies, caddis flies, and mayflies. The life cycle of these insects requires their habitat to
12824 stay inundated with water for 4 to 6 weeks, so their abundance and distribution would continue
12825 to be limited by fluctuations in river stage, especially in the Kootenai River where winter
12826 operations allow for varial zone desiccation, reinundation, and freezing.

12827 **Region B**

12828 The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic
12829 insects such as stonefly, caddisfly, and mayfly larvae. The river elevation in this reach is
12830 influenced by Lake Roosevelt operations and inflows, so it is somewhat variable, which would
12831 constrain benthic production to some degree. Under the No Action Alternative, median
12832 elevations near the U.S.-Canada border (RM 740) would fluctuate during certain times of the
12833 year. When water elevation rises in the September to January and April to June periods, water
12834 levels would allow the recolonization of benthic habitat as areas becomes inundated, but then
12835 any larvae left in the habitats as they dewater from January to April and July to August would
12836 be dried out. This likely limits the production of aquatic insects, especially the larger, longer-
12837 lived species. As the river flows downstream closer to Lake Roosevelt, the influence of reservoir
12838 operations becomes greater. The water levels would follow the same pattern as near the U.S.-
12839 Canada border, but with drops of 42 feet from January through April and 12 feet in July to
12840 August. Within Lake Roosevelt, the elevation changes modeled near Inchelium (RM 680) and
12841 further downstream near the Sanpoil River (RM 616) also followed the same pattern of filling
12842 and dewatering with similar magnitude (42 feet and 12 feet drops) as the stage at RM 720. This
12843 varial zone of the river and reservoir would likely be limited to short-lived, smaller aquatic
12844 insects that could fulfill their life cycle before being desiccated. Longer-lived species would be
12845 limited to the habitats below this annually dewatered zone. The amount of perpetually
12846 inundated habitat would increase as reservoir depth increases closer to Grand Coulee Dam.

12847 In Lake Roosevelt, the production, distribution, and persistence of zooplankton are highly
12848 variable and sensitive to the amount of time the water is in the reservoir (retention time),
12849 which is a function of inflows, reservoir volume, and outflows. The longer water residence
12850 times allow greater abundance and larger-bodied zooplankton to be more widely distributed
12851 throughout the reservoir. Lower retention times result in fewer and smaller-bodied
12852 zooplankton that get concentrated near the dam, where they would be subject to high rates of
12853 entrainment. Zooplankton are the foundation of the food web in Lake Roosevelt, being the
12854 primary prey source for many of the key fish species at one life stage or another. Generally
12855 speaking, under the No Action Alternative, median retention time would range from about 40
12856 to 50 days in the winter and early spring, dropping as low as 21 days by June, and then
12857 gradually increase over the summer to about 45 days at the end of August. September and
12858 October would have high retention times with a median of 60 to 80 days.

12859 Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with
12860 steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short
12861 retention time and low productivity. Here the macroinvertebrate community consists of
12862 production of aquatic insects similar to upstream of Lake Roosevelt, as well as the zooplankton
12863 entrained out of Lake Roosevelt. Regarding aquatic insect production and desiccation, the stage
12864 at RM 594 in Rufus Woods Lake shows about a 4-foot drop in the month of March, and a
12865 double peak in June and July. This means the elevation would increase from April to early June,
12866 peaking at a median of 966 feet, then drop sharply in June to 961 feet, then up again in early
12867 July to 964 feet and drop again to 959 feet in early September. This hydrologic regime would
12868 allow for a fairly long insect growing season with stable or rising elevation for 6 months from
12869 September through February. However, two desiccation periods in the 5-foot range, one in
12870 June and another in July and August, would likely really limit the growth and production of
12871 larval insects in the summer.

12872 Reservoirs and river stretches below Rufus Woods Lake are run-of-the-river and so would
12873 follow similar patterns, with a double-peak in elevation changes in June and July, but the
12874 magnitude of the drop would be attenuated downstream to about a foot or less for much of
12875 this reach. These variations in stage would somewhat limit production of aquatic insects but
12876 would continue to provide habitat for production similar to current levels.

12877 **Region C**

12878 Benthic production in the Dworshak Reservoir is low due to the extensive variation in water
12879 surface elevation, near-shore wave action that causes erosion, and the lack of aquatic plants
12880 along the shoreline (Corps 1992 and 2015). Dworshak Reservoir pool volume typically would
12881 reach full pool on July 1, and then decline rapidly over the summer, providing a limited euphotic
12882 zone for zooplankton production.

12883 The benthic macroinvertebrate community of the lower Snake River has been investigated on
12884 several occasions since the reservoirs were created. The most common taxa observed in the
12885 soft substrate in the Lower Snake River reservoirs were oligochaetes, amphipods (primarily
12886 corophidae), nematodes, diptera (primarily chironomids), and pelecypoda (primarily mussels).

12887 In the hard substrate, diptera (again primarily chironomids), tricoptera (primarily caddis flies),
12888 and amphipods (both bammaridae and corophidae), according to Bennett et al. (1997) as
12889 reported by the Corps (2014). A review of mollusk diversity (Corps 2014) noted that the current
12890 mollusk fauna is dominated by the Asian clam (*Corbicula fluminea*), which became established
12891 in the Columbia River in the 1940s. The California floater (*Anodonta californiensis*), a
12892 Washington State species of concern, was also found in the sampling. The shortface lanx
12893 (*Fisherola nuttallii*) as well as three other snails (western floater [*A. kennerlyi*], knobby rams
12894 horn [*Vorticifex effuse*], and creeping ancyliid [*Ferrissia rivularis*]), and the bivalve western
12895 ridged mussel (*Gonidea angulata*) were also found in small numbers. Crayfish have also been
12896 found in the reservoirs (Curet 1993; Bennett et al. 1995a; Arntzen et al. 2012). The Lower Snake
12897 River reservoirs would continue to provide production of these aquatic macroinvertebrates
12898 with a low diversity of species. Crayfish would continue to thrive in the habitats provided by
12899 rock substrate and riprap. Riverine stretches elevations would vary seasonally but generally
12900 produce similar levels of macroinvertebrates as in current conditions.

12901 **Region D**

12902 Very little benthic macroinvertebrate information is available for the lower Columbia River. Of
12903 those studies completed, oligochaetes, the amphipod *Corophium*, ostracods (seed shrimp),
12904 chironomids (non-biting midge larvae), nematodes, pelecypods (bivalve mollusks), hydracarina
12905 (water mites), and nemertean (proboscis worms) were identified. Samples collected in most
12906 months also contained relatively low densities of ephemeroptera (mayflies), tricoptera
12907 (caddisflies), ceratopogonidae (biting midges), mysids (opossum shrimp), gastropods, and
12908 turbellarians. For most major taxa, densities were relatively high in the spring, declined to
12909 seasonal lows during summer, then increased to relatively high levels in the fall. Taxa present at
12910 lower densities during the summer months included nemertean, which were frequently most
12911 abundant in autumn, pelecypods, and ostracods. *Corophium* differed most notably from this
12912 seasonal trend in that higher *Corophium* densities were observed during the summer months
12913 than during fall. The run-of-river dams would continue to be operated at stable elevations that
12914 would continue production of these aquatic macroinvertebrates.

12915 **SUMMARY OF EFFECTS**

12916 **Anadromous Fish**

12917 A variety of factors affect juvenile migration and survival at the Columbia and Snake River
12918 projects. These include project structures, dam passage modifications, natural mortality, and
12919 predation. Adult migration is affected by dam passage, predation, and temperature and flow
12920 conditions. The measures in the No Action Alternative are not expected to change these
12921 factors, although temperature and flow conditions may be impacted by climate change (See
12922 Chapter 4 Climate Change).

12923 In addition, steelhead and salmon populations in the Columbia River basin are heavily
12924 influenced by many factors unrelated to the operations and configuration of the CRS and some
12925 that occur outside of the system. These factors include competition and interbreeding with

12926 hatchery stocks; commercial, recreational, and tribal fish harvest; habitat conditions including
12927 water quality in the tributaries and migratory river corridors and yearly and decadal changes in
12928 the ocean rearing environment. Factors outside of the CRS are described throughout this
12929 document, but in general are expected to continue to influence anadromous fish in addition to
12930 the impacts associated with CRS. The trend that each species has exhibited for the past 20
12931 years, whether upward, downward, or steady, is expected to continue under the No Action
12932 Alternative.

12933 **Resident Fish**

12934 Key effects are likely to continue to resident fish under the No Action Alternative. These effects
12935 include elevated summer water temperatures; elevated TDG; federal and non-federal dams
12936 that pose migration barriers, cause passage delays, or increase fish mortality; reductions in
12937 spawning and rearing habitats and changes in flow patterns and temperatures that reduce
12938 spawning and recruitment success. Elevated water temperatures would have beneficial effects
12939 to warm water resident fish and minor adverse effects to bull trout. TDG would have minor
12940 adverse effects to resident species. Non-native fish would likely continue to increase with
12941 suitable water conditions. White sturgeon would continue to successfully reproduce in some
12942 water years with adequate flow and temperature conditions, and bull trout would continue to
12943 seek thermal refugia as they migrate through the Columbia River. Reservoir operations that
12944 cause fluctuations in water elevations would continue to limit productivity and reduce access to
12945 tributary habitats in storage reservoirs, while, non-native invasive species would likely continue
12946 to increase in number and area.

12947 **Macroinvertebrates**

12948 Macroinvertebrate communities would continue to thrive in the aquatic environments provided
12949 by CRS project reservoirs and riverine stretches. Abundance and distribution would continue to
12950 be limited by fluctuations in reservoir elevations and river stages.

12951 **3.5.3.4 Multiple Objective Alternative 1**

12952 **ANADROMOUS FISH**

12953 **Salmon and Steelhead**

12954 Several different ESUs of salmon and DPS of steelhead share a similar life cycle and experience
12955 similar effects from the MOs, but also have ESU or DPS specific traits that specifically drive
12956 effects differently from one another. Common effects analyses across all salmon and steelhead
12957 are discussed first, and then those ESU or DPS specific effects are displayed. Unless otherwise
12958 noted, quantitative results from COMPASS or CSS models or the Life Cycle Model (LCM) are
12959 based on a combination of hatchery and natural origin fish. This applies for both juvenile and
12960 adult results.

12961 ***Effects Common Across Salmon and Steelhead***

12962 Summary of Key Effects

12963 MO1 includes several structural measures intended to improve juvenile migration, the block
12964 spill operations will generally increase the amount of spill at each of the lower Columbia River
12965 and lower Snake River projects for improved juvenile survival, and predator disruption
12966 operations at John Day would reduce juvenile predation by Caspian terns. During periods of
12967 increased spill, latent effects may be reduced for fish under those conditions, which could
12968 potentially increase ocean survival for those fish. Structural measures in MO1 would make
12969 small, incremental improvements in adult migration, but operational changes at Dworshak that
12970 were intended to improve thermal conditions for adult migrations in the lower Snake River
12971 actually would reduce adult migration success. Models predict that returns of salmon and
12972 steelhead would be similar or slightly higher compared to the No Action Alternative depending
12973 on species and on analytical model.

12974 Juvenile Fish Migration/Survival

12975 There are several structural measures in MO1 that may affect juvenile salmon and steelhead.
12976 Many of these structures are in one or more other MOs as well. The effects of these measures
12977 are described here and are briefly summarized where they appear in other MOs.

- 12978 • *Additional Powerhouse Surface Passage* at McNary and Ice Harbor Projects.

12979 The percent of fish passing through turbine routes at a given project depends on flows
12980 and operations. Performance standard testing conducted at projects found the percent
12981 of fish that experienced turbine routes varied from 3 percent at the McNary Project to
12982 12 percent at the Lower Granite Project. Because turbine routes generally have lower
12983 survival (87 to 95 percent), powerhouse surface passage routes were proposed to route
12984 additional fish to spillway or spillway like routes. For modeled species, the effects of
12985 powerhouse passage were incorporated into the COMPASS and CSS modeling directly.
12986 For COMPASS modeling, surface passage efficiencies for yearling Chinook salmon and
12987 steelhead of 40 and 50 percent respectively, were fed directly into model runs, while
12988 CSS modelers provided results with surface passage efficiencies of 10, 20, and 30
12989 percent. From CSS modeling runs, for comparisons between MOs, a 30 percent passage
12990 efficiency was used. Even with the most optimistic 30 percent passage efficiency
12991 assumption in place, the effect of these powerhouse surface passage structures on in-
12992 river survival and subsequent adult returns was minor. These structures could
12993 potentially be more effective at influencing population level dynamics at lower spill
12994 levels than those included in MO1, but with the combination of up to 115%/120% TDG
12995 spill and performance standard spill, there were not enough fish passing via the
12996 powerhouse to have a meaningful impact.

12997 For those species that were not modeled, effects of powerhouse surface passage routes
12998 were described qualitatively. This would include improved juvenile survival. For dams
12999 with existing spillway surface weirs, forebay delay is insignificant under the No Action

- 13000 Alternative so there is little expectation of large decreases in forebay travel times. The
13001 addition of powerhouse surface passage structures would route additional fish away
13002 from turbine passage routes to spillway or spillway-like routes where they generally
13003 have higher survival.
- 13004 • Upgrade spillway weirs to ASWs at Lower Granite, Lower Monumental, Ice Harbor, McNary,
13005 and John Day Dams
- 13006 The design of spillway weirs is different from existing spillways. Existing spillway gates
13007 open 50 feet below the water surface at the face of the dam and pass juvenile fish
13008 under high pressure and high velocities, while spillway weirs pass juvenile salmon and
13009 steelhead over a raised spillway crest near the water surface. Because juvenile salmon
13010 and steelhead migrate primarily in the upper 10 to 20 feet of the water column, spillway
13011 weirs are easier to find and are less stressful for fish passage. Weirs are effective in
13012 attracting about one-third of all juveniles passing the dams with survival rates over 98
13013 percent at most projects.
- 13014 ASWs are a newer generation of weir that increase the flexibility of managers to attract
13015 juvenile fish to the weir under a wider range of water flows. Effects are similar to
13016 temporary spillway weirs and removable spillway weirs. However, an ASW has a wider
13017 range of operation, flows can be increased in the spring to attract more fish and reduce
13018 flows in the summer to prolong operation. Effects of these weirs would include
13019 increased juvenile survival, reduced migration delays for juveniles, and increased
13020 operating range from high flows in spring and early summer to low flows in late summer
13021 and fall. In addition, these weirs allow for more flexibility in managing flows to improve
13022 tailrace conditions so that juvenile fish can pass quickly and avoid predation.
- 13023 • *Improved Fish Passage Turbines* at John Day Project
- 13024 Turbines at the John Day Project are scheduled for replacement after similar
13025 replacements have been completed at the Ice Harbor (up to three turbines) and McNary
13026 Projects (part of the No Action Alternative). As this measure will follow the Ice Harbor
13027 and McNary improvements, these improvements are currently scheduled to occur
13028 between 2025 and 2039. These new IFP turbines would have similar improvements in
13029 fish passage performance as the replacement turbines designed for install at the Ice
13030 Harbor Project. The Ice Harbor Project turbines were specifically designed for fish
13031 passage using a design process similar to what may be used for future runners at John
13032 Day Project. Turbine mortality was split into direct and indirect mortality. Direct turbine
13033 mortality includes injuries that occur during turbine passage, while indirect turbine
13034 mortality can include effects like predation that occur due to disorientation or poor
13035 egress following turbine passage. The primary sources of direct turbine mortality come
13036 from mechanical-, shear-, or pressure-related injuries.
- 13037 Physical hydraulic models were used to evaluate the potential for mechanical and sheer
13038 related injuries, while potential for pressure related injuries were evaluated using
13039 sensor fish or computation fluid dynamic models. These analyses suggested that IFP

13040 turbines could reduce injury and mortality by as much as 68 percent for fixed-blade
13041 turbines and as much as 49 percent for adjustable blade turbines.

13042 For modeling and analysis purposes, a value of 50 percent was used to evaluate
13043 reductions in injuries to juvenile salmon and steelhead that pass through turbine routes.
13044 COMPASS modeling incorporates these values directly into the model, and the results
13045 reflect the change in survival. For non-modeled species, qualitative analyses and
13046 surrogate species were used to evaluate effects of new IFP turbines. See appendix E for
13047 more information regarding these assumptions.

13048 Several operational measures warrant discussion here individually, regarding effects to
13049 juvenile fish. Measures that would result in changes to spill, flows, passage routes, or
13050 temperatures were incorporated into the fish models. Others are not readily
13051 incorporated into modeling for effects analysis, or are modeled but may be difficult to
13052 separate from other factors, and so effects of these measures are discussed
13053 qualitatively.

13054 • *Predator Disruption Operations.* Bird predators, including Caspian terns, ring-billed and
13055 California gulls have been shown to consume large numbers of juvenile salmon and
13056 steelhead during their downstream migration to the ocean. Blalock Islands are situated in
13057 the John Day Project pool and provide nesting habitat for colonies of Caspian terns and
13058 gulls. Under the No Action Alternative, approximately 500 breeding pairs of Caspian terns
13059 consume nearly 150,000 steelhead at these small islands annually. This measure calls for a
13060 change in operation to raise water levels in the John Day Project pool in April and May to
13061 elevations between 263.5 and 265 feet. Effects of this operation would greatly reduce
13062 potential nesting habitat for Caspian terns at the Blalock Islands. In fact, an increase in
13063 elevation of 1 foot, from 263.5 to 264.5 feet, would reduce habitat by approximately 90
13064 percent. Recent studies show that regional efforts to dissuade Caspian tern nesting have led
13065 to a decline in Caspian tern population of approximately 44 percent (Roby 2019
13066 presentation). Continued reductions in nesting habitat would likely be associated with
13067 continued reductions in nesting predators and increases in juvenile salmon and steelhead
13068 survival.

13069 • *Block Spill Test (Base + 120/115%):* A spring block spill test of alternating units of
13070 115%/120% TDG spill (high spill block) and performance standard based spill (lower spill
13071 block). This operation would increase the proportion of spill at each of the lower Columbia
13072 River and lower Snake River projects. The high spill block would have the net effect of
13073 routing increased numbers of juvenile salmon and steelhead into spill routes and fewer
13074 through other routes, such as the juvenile fish bypasses and turbine routes. Spill levels, spill
13075 patterns, and turbine priorities also have significant effects on the survival rates of
13076 migrating juveniles via their influence on tailrace hydraulics and the formation of eddies.
13077 For juvenile salmon and steelhead, fish modeling was used when available to estimate the
13078 effects of these spill changes on fish. Increased spill could provide potential benefits to
13079 salmon and steelhead if delayed mortality is considered in relation to powerhouse
13080 encounters (see section 3.5.3.1 Comparison of CSS and COMPASS Models). The CSS
predicts

13081 that increased spill could substantially reduce latent mortality of juvenile yearling Chinook
13082 salmon moving downstream through the mainstem dams, and this outcome is reflected in
13083 the outputs of abundance in the CSS model. If this were to occur for other salmon and
13084 steelhead, SARs would also be improved. The spring block spill operation was specifically
13085 designed to test the impact of latent mortality due to passage through the CRS in a
13086 scientifically robust manner (see ISAB 2018-2).

13087 Increasing the operating range by 6 inches at the lower Snake River Dams and at John Day
13088 Dam relative to the No Action Alternative would slightly increase juvenile fish travel times
13089 and exposure to predators. Travel time effects were included in the fish models.

13090 The combination of all measures that affect flow patterns in the Lower Columbia River.
13091 These measures would result in changes in MO1 relative to the No Action Alternative,
13092 such as one to three percent decreases in monthly average flows March to July, a
13093 decrease of five to six percent in monthly average flow in August, and one to seven
13094 percent higher flows in December. In the lower Snake River, August flows would be 13
13095 to 16 percent lower than the No Action Alternative, and 7 to 9 percent higher in
13096 September. Reductions in August flows were primarily driven by the measure to modify
13097 Dworshak flows to influence temperature but had the unintended and unexpected
13098 result of reducing flows while not affecting temperatures (see additional discussion in
13099 Adult Fish Migration/Survival below). Similar to the spill changes, fish modeling was
13100 used when available to estimate the effects of these flow changes on juvenile fish.

13101 Adult Fish Migration/Survival

13102 There are several structural measures in MO1 that may affect adult salmon and steelhead.
13103 Many of these structures are in one or more other MOs as well. The effects of these measures
13104 are described here and will be briefly summarized where they appear in other MOs.

- 13105 • *Lower Granite Trap Modifications.*

13106 The adult fish trap at the Lower Granite Project is equipped with a weir gate that swings
13107 open in a turn pool above the trap. The gate diverts fish into the trap for data collection
13108 and trap and haul. The gate is difficult to operate and open. Consequently, the gate is
13109 rarely taken out of service and is generally closed, even when the trap is not in
13110 operation. This leads to delays in migration, occasional clogging from debris or dying
13111 shad, and blockage of downstream migrating fish. In addition, the design of the ladder
13112 creates delays in lamprey migration as they try to get over the bottom bar.

13113 Changing the gate to make it easier to operate would improve fish passage and reduce
13114 delays and clogging on days when the trap is not in operation. In addition, a redesign of
13115 the trap gate would allow for lamprey passage by leaving a slot in the bottom large
13116 enough for them to pass under it. These improvements would improve adult conversion
13117 and survival, reduce delays in migration, and aid in volitional downstream passage
13118 through the ladder.

13119 • *Modify Bonneville Ladder Serpentine Weir.*

13120 At Bonneville Dam's Bradford Island and Washington Shore ladder flow control sections,
13121 the baffles that help slow velocities and control flows do not allow for direct line
13122 movement of fish passing the dam but requires fish to weave through the baffles. The
13123 modification of these baffles would include allowing for direct faster movement through
13124 the ladder by replacing them with ones that have in-line vertical slots and orifices.

13125 This measure has the potential to increase adult salmon and steelhead survival by
13126 reducing upstream travel times and higher conversion rates. A similar modification at
13127 John Day Dam, the only other CRS dam to use this type of ladder, resulted in major
13128 passage time reductions for salmon and steelhead. Similar improvements are expected
13129 for Bonneville Dam. In addition, these improvements would reduce migration delays
13130 and barriers for Pacific lamprey.

13131 • *Lower Snake Ladder Pumps.*

13132 During hot summer months, warm surface water is often entrained into fish ladders at
13133 the Lower Monumental and Ice Harbor Projects, leading to a difference in temperatures
13134 between the water exiting the ladder in the tailrace and the main river within the
13135 tailrace. When these abrupt differences in temperature at ladder entrances exceed 2°C,
13136 they can lead to delays and even create barriers in fish migration as adults search for
13137 cooler passage routes.

13138 Installing pumps in the Lower Monumental and Ice Harbor Projects' forebays to supply
13139 water to the ladders from deeper and cooler sources would cool the ladders and reduce
13140 differences in temperature if colder water is available at deeper depths. These changes
13141 would reduce adult migration delays and barriers and would improve adult survival and
13142 conversion.

13143 The following measures are described in detail in the juvenile fish section above. In
13144 addition to juvenile benefits, they could have the following effects on adult migration
13145 and survival:

- 13146 ○ The Additional Powerhouse Surface Passage measure at McNary and Ice Harbor Projects
13147 could reduce forebay travel time and improve downstream migration of steelhead kelts.
- 13148 ○ Upgrading spillway weirs to AWSs at Lower Granite, Lower Monumental, Ice Harbor,
13149 McNary, and John Day Dams would reduce migration delays for steelhead kelts.
- 13150 ○ The Improved Fish Passage Turbines measure at the John Day Project would increase
13151 survival of salmon and steelhead that overshoot the John Day Project as well as
13152 steelhead kelts that pass back downstream through turbines.

13153 Overall, MO1 contains structural measures at lower Columbia River and lower Snake River
13154 projects that may reduce delay for adult fish passing those projects; however, adult fallback
13155 rates may also increase under MO1 due to higher spill levels, which could increase adult fish

13156 delay (Boggs et al. 2004; Keefer et al. 2005). It is important to note that regional managers use
13157 in-season adaptive management to identify and remedy any excessive fallback.

13158 Specific to adult salmon and steelhead passing through the lower Snake in July to September,
13159 the *Modified Dworshak Summer Draft* measure in MO1 was intended to provide cooler water
13160 during more targeted periods when the cooler water could make a difference for upstream
13161 migration conditions. However, the water quality effects analysis showed that this measure did
13162 not have the intended effect on cooling the lower Snake River corridor appreciably below 20°C
13163 during July and September in periods when water temperatures were otherwise above that
13164 threshold, and furthermore exacerbated warm water temperature issues in the August
13165 timeframe.

13166 ***Upper Columbia River Salmon and Steelhead***

13167 Upstream of McNary Dam, upper Columbia salmon and steelhead migrate past as many as five
13168 non-federally owned dams and reservoirs, which also influence the survival and passage of
13169 these species. The federal agencies do not dictate generation or spill levels at the PUD projects
13170 so metrics such as powerhouse encounter rate are not directly affected but are influenced by
13171 river flow levels coming through the upper Basin. The timing and volume of flow levels affected
13172 by CRS operational decisions are reflected in model analysis. COMPASS and LCM estimates of
13173 powerhouse encounter rate and SARs include passage effects from a combination of federal
13174 and PUD dam passage (Rock Island Dam to Bonneville Dam). CSS model results are not available
13175 for upper Columbia stocks.

13176 Upper Columbia Spring-Run Chinook Salmon

13177 *Summary of Key Effects*

13178 The COMPASS modeling results support the qualitative expectations that the MO1 survival
13179 rates from McNary Dam to Bonneville Dam would increase slightly and travel times would be
13180 reduced slightly. Predator disruption operations would further increase juvenile survival.
13181 Structural improvements and reduced flows would increase adult migration success, but higher
13182 spill blocks may cause additional fallback and delay compared to the No Action Alternative.
13183 Abundance would increase by 6 percent or more if latent mortality were reduced.

13184 *Juvenile Fish Migration/Survival*

13185 This ESU migrates through the Columbia River downstream past the four lower CRS projects
13186 and up to five PUD owned dams. Structural and operational measures in the Common Effects
13187 section that describe changes from the No Action Alternative at McNary, John Day, The Dalles,
13188 and Bonneville Projects would apply to these fish. COMPASS modeling estimates that MO1 is
13189 expected to result in a 0.5 percent increase in average juvenile survival for upper Columbia
13190 River spring, a 5 percent decrease in average juvenile travel time from McNary Dam to
13191 Bonneville Dam, and a 6 percent decrease in the number of powerhouse passage events.
13192 Predator disruption operations, also described in Common Effects, would further increase

13193 juvenile survival by reducing predation on outmigrating smolts. TDG exposure would be the
13194 same as the No Action Alternative for these fish. CSS cohort modeling for upper Columbia River
13195 spring-run Chinook salmon was not available for this analysis.

13196 Table 3-72 summarizes COMPASS and TDG Tool model results for upper Columbia River spring-
13197 run Chinook salmon under MO1.

13198 **Table 3-72. Multiple Objective Alternative 1 Juvenile Model Metrics for Upper Columbia River**
13199 **Spring-Run Chinook Salmon**

Metric (Model)	NAA	MO1	Change from NAA	% Change
Juvenile Survival (COMPASS) McNary to Bonneville	69.5%	70.0%	+0.5%	N/A
Juvenile Travel Time (COMPASS) McNary to Bonneville	6.1 days	5.8 days	-0.3 days	-5%
% Transported (COMPASS)	No transport of upper Columbia Chinook			
Powerhouse Passages (COMPASS) Rock Island to Bonneville	3.29	3.08	-0.21	-6%
TDG Average Exposure (TDG Tool)	115.9% TDG	116% TDG	-0.1 % TDG	N/A

13200 *Adult Fish Migration/Survival*

13201 The *Modify Bonneville Ladder Serpentine Weir* measure, described in the Common Effects
13202 section, could decrease delay of upstream migrations, although higher spill periods of block spill
13203 could increase fallback rates. Adult exposure to TDG would be similar to the No Action
13204 Alternative.

13205 The NWFSC LCM estimated SARS and abundance of the Wenatchee population. NWFSC LCM
13206 results predict abundance of the Wenatchee population, indicative of this ESU, could result in a
13207 slight increase of about 1 percent relative to the No Action Alternative (0.96 percent compared
13208 to 0.95 percent), assuming latent mortality was the same as in the No Action Alternative.
13209 Abundance estimates produced by the NWFSC Life Cycle model were also considered with a
13210 range of potential outcomes based on hypothetical increases in production that could be
13211 associated with reductions in latent mortality effects. While CSS modeling was not available for
13212 this population, the relationships in CSS modeling that indicate fewer powerhouse encounters
13213 would reduce latent mortality may apply to this population as well. If the 23 percent lower
13214 powerhouse encounter rate were to lower latent mortality that would subsequently increase
13215 ocean survival, abundance could increase more than 6 percent (Table 3-73).

13216 **Table 3-73. Multiple Objective Alternative 1 Model Metrics for Adult Upper Columbia River**
13217 **Spring Chinook Salmon**

Metric (Model)	NAA	MO1	Change from NAA	% Change
Rock Island to Bonneville SARs (NWFSC LCM)	0.94%	0.95%	+0.01%	+1%
NWFSC LCM abundance range with decreased latent mortality ¹ (number of adults)	498	526 (0%)	+28 (0%)	+6% (0%)
		570 (10%)	+72(10%)	+14% (10%)
		690 (25%)	+192 (25%)	+39% (25%)
		822 (50%)	+324 (50%)	+65% (50%)

13218 ¹ NWFSC LCM does not factor latent mortality due to the Columbia River System into the SARS or abundance
13219 output. For discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent
13220 are shown. The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values
13221 represent scenarios of what SARs, or abundance hypothetically could be under the increased ocean survival if
13222 changes in the alternative were to decrease latent mortality by that much.

13223 Upper Columbia River Steelhead

13224 *Summary of Key Effects*

13225 There are no life cycle models for upper Columbia steelhead to estimate adult returns, only
13226 COMPASS model estimates of juvenile downstream survival. Functionally, upper Columbia River
13227 steelhead juvenile migration would be about the same as the No Action Alternative. Modeled
13228 survival shows a 0.2 percent decrease, but travel time would be the same as the No Action
13229 Alternative, and powerhouse encounters would be lower. Predator disruption operations would
13230 further increase juvenile survival. Structural improvements and reduced flows could increase
13231 adult migration success. Structural measures and higher spill blocks described in the Common
13232 Effects section, including the Additional Powerhouse Surface Passage and Improved Fish
13233 Passage Turbines measures, may increase kelt survival by reducing the proportion that go
13234 through turbine routes.

13235 *Juvenile Fish Migration/Survival*

13236 Juveniles from this DPS migrate through the Columbia River downstream past the four lower
13237 CRS projects and up to five PUD owned dams in the mid-Columbia. Operations at upstream
13238 reservoirs that affect seasonal flow patterns downstream influence travel time and survival at
13239 the PUD owned projects. Structural and operational measures described in the Common Effects
13240 section, including the *Additional Powerhouse Surface Passage* measure at the McNary and John
13241 Day Projects, and the *Upgrade to Adjustable Spillway Weirs* measure at the McNary and John
13242 Day Projects, would decrease powerhouse passage events, as indicated in the modeling.
13243 Overall, however, COMPASS modeling estimates that MO1 is expected to result in a 0.2 percent
13244 decrease in average juvenile survival for upper Columbia steelhead, travel time would be the
13245 same as the No Action Alternative, and powerhouse passage events would decrease 5 percent.
13246 The *Predator Disruption Operations* measure, also described in Common Effects, would further
13247 increase juvenile survival by reducing predation on outmigrating smolts. TDG exposure and the
13248 resulting effect on juvenile survival would be similar to the No Action Alternative for these fish.

13249 Table 3-74 summarizes COMPASS and TDG Tool model results for upper Columbia River
13250 steelhead under MO1. CSS cohort modeling for upper Columbia spring-run Chinook was not
13251 available for this analysis.

13252 **Table 3-74. Multiple Objective Alternative 1 Model Metrics for Juvenile Upper Columbia**
13253 **Steelhead**

Metric (Model)	NAA	MO1	Change from NAA	% Change
Juvenile Survival (COMPASS) McNary to Bonneville	65.8%	65.6%	-0.2%	-0%
Juvenile Travel Time (COMPASS) McNary to Bonneville	6.6 days	6.7 days	+0.1 days	0%
% Transported (COMPASS)	No transport of upper Columbia steelhead			
Powerhouse Passages (COMPASS) Rock Island to Bonneville	2.72	2.59	-0.13	-5%
TDG Average Exposure (TDG Tool) McNary to Bonneville	116% TDG	116.1% TDG	-0.1% TDG	N/A

13254 *Adult Fish Migration/Survival*

13255 The *Modify Bonneville Ladder Serpentine Weir* measure, described in the Common Effects
13256 section, would decrease delay of upstream migrations. Structural measures designed to
13257 increase juvenile survival (*Additional Powerhouse Surface Passage at McNary and John Day,*
13258 *and Upgrade to Adjustable Spillway Weirs at McNary and John Day Projects*) would also benefit
13259 kelt survival by increasing the proportion of downstream migrating kelts going through turbine
13260 routes. Higher spill periods of block spill could increase survival of kelts by increasing non-
13261 turbine routes. Adults migrate in late summer and early fall, so 5 to 6 percent lower outflows in
13262 the lower Columbia River in August could increase upstream migration success. Adult exposure
13263 to TDG would be similar to the No Action Alternative, as the total number of days TDG would
13264 exceed the water quality standard would be lower than the No Action Alternative at McNary,
13265 John Day, and The Dalles Dams; at Bonneville Dam, there would be 1 more day than the No
13266 Action Alternative. Temperatures would also be very similar to No Action Alternative. The
13267 number of days exceeding state temperature standards at the four lower river projects would
13268 be less than 1 percent higher than the No Action Alternative.

13269 Upper Columbia River Coho Salmon

13270 See upper Columbia spring-run Chinook salmon analysis as a surrogate for juvenile upper
13271 Columbia coho salmon and upper Columbia fall Chinook salmon analysis as a surrogate for
13272 adult upper Columbia coho salmon.

13273 *Summary of Key Effects*

13274 The primary challenges for upper Columbia River coho salmon are the conditions they
13275 encounter during upstream and downstream migrations. Downstream survival and migration
13276 for juveniles is dependent on water flow and routing at the dams. Higher flows and higher spills

13277 generally lead to higher survival. Juvenile coho survival would be similar to upper Columbia
13278 River spring-run Chinook salmon, with structural measures and spill increases potentially
13279 increasing juvenile survival and additional increases in survival due to lower avian predation in
13280 the John Day area. Adult coho salmon migration timing is similar to upper Columbia River fall
13281 Chinook salmon so that species is used as a surrogate for upstream migration effects.

13282 *Juvenile Fish Migration/Survival*

13283 See upper Columbia River spring-run Chinook salmon results as a surrogate for juvenile upper
13284 Columbia River coho salmon.

13285 *Adult Fish Migration/Survival*

13286 Adult migration conditions would be similar to upper Columbia Fall Chinook, which were
13287 analyzed in a workshop using water quality and hydrology information. MO1 water quality
13288 modeling showed no change in the frequency of water temperatures exceeding 20°C relative to
13289 the No Action Alternative, but a higher incidence of adult ladder temperature differentials
13290 above 2°C, which could delay upstream migration. Upper Columbia coho salmon migrate
13291 upstream as adults in August/September (early run) and October/November (late run), so
13292 migration success of a portion of the early run may be affected with 5 to 6 percent lower flows
13293 in August. See upper Columbia Fall Chinook salmon results as a surrogate for adult upper
13294 Columbia coho salmon.

13295 Upper Columbia River Sockeye Salmon

13296 Refer to the upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia
13297 River sockeye salmon.

13298 *Summary of Key Effects*

13299 MO1 would result in similar or minor improvements in juvenile migration over the No Action
13300 Alternative. Survival would be similar to upper Columbia River spring-run Chinook salmon, with
13301 structural measures and spill increases resulting in potentially minor increases in juvenile
13302 survival, and additional increases in survival due to lower predation by birds in the John Day
13303 area. Adult migration would be similar to the No Action Alternative.

13304 *Juvenile Fish Migration/Survival*

13305 Juvenile survival of upper Columbia River sockeye salmon is estimated using COMPASS juvenile
13306 modeling results for upper Columbia River spring-run Chinook salmon as a surrogate.

13307 MO1 would have negligible increases in survival rates for juvenile sockeye passing downstream
13308 through the lower Columbia River compared to the No Action Alternative; travel time and
13309 powerhouse encounters would exhibit minor decreases. Structural measures, such as the
13310 *Additional Powerhouse Surface Passage* measure at the McNary and John Day Projects and the
13311 *Upgrade to Adjustable Spillway Weirs* measure at the McNary and John Day Projects, as well as
13312 the *Predator Disruption Operations* measure described in Common Effects would increase

13313 survival by increasing proportions of fish to pass through the spillways. This is in addition to
13314 increased survival of sockeye juveniles passing through John Day Dam turbines.

13315 Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia
13316 River sockeye salmon, for additional information in modeled juvenile fish migration and survival
13317 metrics.

13318 *Adult Fish Migration/Survival*

13319 The summer water temperatures in the river during the upstream migration would be similar to
13320 the No Action Alternative, with thermal issues continuing to reduce adult survival in warm
13321 years, and TDG exposure would be similar to the No Action Alternative. Structural improvement
13322 of the *Modify Bonneville Ladder Serpentine Weir*, described in Common Effects at the
13323 Bonneville Project, could reduce migration delay.

13324 Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia
13325 River sockeye salmon, for additional information in modeled adult fish migration and survival
13326 metrics.

13327 Upper Columbia River Summer/Fall-Run Chinook Salmon

13328 *Summary of Key Effects*

13329 Juvenile upper Columbia summer/fall-run Chinook salmon would be similar to the No Action
13330 Alternative, with potential increases in juvenile survival due to lower predation in the John Day
13331 Dam pool. There may be slightly greater adult migration delay due to higher incidence of adult
13332 ladder temperature differentials above 2°C.

13333 *Larval Development/Juvenile Rearing in Mainstem Habitats*

13334 None of the measures of MO1 would change the substrate sizes or distribution in the spawning
13335 areas or expand suitable spawning areas; therefore, this alternative is expected to have the
13336 same larval development and juvenile rearing habitat conditions as the No Action Alternative.
13337 The same is true for river depths in the spawning areas; no change is anticipated for eggs
13338 incubating in the gravel. Once juvenile Chinook salmon have emerged and moved to the
13339 reservoirs for rearing, lack of summer cooling water may reduce quality of rearing habitat for
13340 fish that holdover for their first year; however, the changes for MO1 would not be a
13341 measurable difference compared to the No Action Alternative. No change is anticipated in
13342 McNary and John Day Dam reservoir plankton communities or shoreline habitats under MO1,
13343 relative to the No Action Alternative. Likewise, juvenile rearing habitat below Bonneville Dam is
13344 not expected to change relative to the No Action Alternative.

13345 *Juvenile Fish Migration/Survival*

13346 Juvenile summer/fall-run Chinook salmon are especially susceptible to predation in the
13347 Columbia River from the Okanogan River to downstream of McNary Dam. Water temperatures

13348 would be the same as the No Action Alternative and would not change predation rates in this
13349 reach. Downstream migration of juveniles would be similar to the No Action Alternative as well.

13350 *Adult Fish Migration/Survival*

13351 The number of days water temperatures in the McNary Dam tailrace exceed 20°C would not
13352 change relative to the No Action Alternative, so no change in migration delay, fallback, or
13353 susceptibility to disease are anticipated due to overall warmer mainstem water temperatures at
13354 the lower Columbia River Dams. However, the number of days that adult ladder water
13355 temperatures were greater than 2°C in difference would increase from 2.8 percent of days (No
13356 Action Alternative) to 4.2 percent of days (MO1), which may slightly increase the delay in dam
13357 passage for adult fish (Caudill et al. 2013).

13358 Specific to Okanogan upper Columbia River summer/fall-run Chinook salmon, there would be
13359 no change in the number of days the mainstem would be 20°C or higher at the confluence of
13360 the Okanogan River, relative to the No Action Alternative. This means that there would be no
13361 change anticipated in the ability of the Okanogan fish to wait (hold) in the mainstem until water
13362 temperatures in the Okanogan River are cool enough for adults to move up from the mainstem
13363 without having to migrate through water temperatures typically considered lethal for salmon
13364 and steelhead (Ashbrook et al. 2009).

13365 The frequency of meeting the Vernita Bar Agreement to protect fall-run Chinook salmon
13366 spawning in and around the Hanford Reach of the Columbia River in Washington is not
13367 expected to change under any MOs relative to the No Action Alternative. Other operational
13368 changes under the MOs are likewise not anticipated to affect upper Columbia River
13369 summer/fall-run Chinook salmon spawning from the tailrace of Chief Joseph Dam to Bonneville
13370 Dam in terms of changes in flows, water temperatures, or TDG generated under the MOs.

13371 ***Middle Columbia River Salmon and Steelhead***

13372 Middle Columbia River Spring-Run Chinook Salmon

13373 See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River
13374 Spring-Run Chinook Salmon.

13375 *Summary of Key Effects*

13376 Changes in effects to middle Columbia River spring-run Chinook salmon juvenile and adult
13377 migrations and adult returns under MO1 would be similar to the No Action Alternative.

13378 *Juvenile Fish Migration/Survival*

13379 See upper Columbia River spring-run Chinook analysis as a surrogate for juvenile middle
13380 Columbia River spring-run Chinook salmon. Middle Columbia River juvenile salmon would
13381 typically experience higher absolute survival than upper Columbia River spring-run Chinook
13382 salmon because they do not travel as far through the Columbia River System and through up to

13383 five non-federal owned dams. However, the surrogate metric used for upper Columbia River
13384 spring-run Chinook salmon is survival from McNary to Bonneville Dam and would be similar for
13385 middle Columbia spring-run Chinook salmon that pass the same CRS projects.

13386 *Adult Fish Migration/Survival*

13387 Effects to middle Columbia River spring-run Chinook salmon adults would be similar to upper
13388 Columbia River spring-run Chinook salmon. Structural improvements and reduced flows would
13389 increase adult migration success, but higher spill blocks may cause additional fallback and delay
13390 compared to the No Action Alternative. See upper Columbia River spring-run Chinook analysis
13391 for surrogate information on adult middle Columbia River spring-run Chinook salmon under
13392 MO1 and comparisons to No Action Alternative.

13393 Middle Columbia River Steelhead

13394 *Summary of Key Effects*

13395 Changes in effects to middle Columbia River steelhead juvenile and adult migration and returns
13396 under MO1 would be similar to the No Action Alternative. Certain structural measures,
13397 including the *Additional Powerhouse Surface Passage* and *Improved Fish Passage Turbines*
13398 measures, and higher spill levels under the *Block Spill Test (Base +120/115%)* measure would
13399 result in higher survival rates for adult steelhead falling back through the dams and kelts
13400 migrating downstream.

13401 *Juvenile Fish Migration/Survival*

13402 Populations of mid-Columbia River steelhead distributed between the Deschutes and Walla
13403 Walla Rivers pass two to four CRS dams in the lower Columbia on their downstream migration
13404 to the ocean. Modeling was not available for middle Columbia River steelhead, so juvenile
13405 survival of upper Columbia steelhead was used as a surrogate of juvenile survival through the
13406 Bonneville project (pool and dam) for this portion of the DPS. COMPASS modeling predicted a
13407 negligible decrease in survival and slower travel times under MO1, compared to the No Action
13408 Alternative. TDG would also be similar to the No Action Alternative. Refer to Upper Columbia
13409 River steelhead analysis (Section 3.5.3.3) for surrogate information on Middle Columbia River
13410 steelhead.

13411 Predator disruption operations, as described in the Common Effects section, would reduce
13412 predation on outmigrating middle Columbia River steelhead smolts and increase juvenile
13413 survival. Functionally, reduced predation rates by Caspian terns between McNary and John Day
13414 dams that would result in increased juvenile survival, combined with reduced survival between
13415 McNary and Bonneville dams would likely result in similar survival of middle Columbia River
13416 steelhead in MO1 compared to the No Action Alternative.

13417 *Adult Fish Migration/Survival*

13418 Structural measures such as *Modify Bonneville Ladder Serpentine Weir* are expected to reduce
13419 delay associated with upstream passage. Higher spill levels during April periods under the *Block*
13420 *Spill Test (Base + 120/115%)* measure would result in higher survival rates for adult steelhead
13421 falling back through dams and kelts migrating downstream, as fewer adults would use
13422 powerhouse passage routes with increased availability of spill routes. Downstream passage
13423 survival would also increase when surface passage was available (Normandeau et al. 2014;
13424 Richins and Skalski 2018).

13425 ***Snake River Salmon and Steelhead***

13426 Snake River Spring/Summer-Run Chinook Salmon

13427 *Summary of Key Effects*

13428 Modeling and qualitative analyses indicate that MO1 would result in similar or slightly higher
13429 overall returns of Snake River spring/summer-run Chinook salmon. Juvenile survival would be
13430 very similar to the No Action Alternative (about 0.5 percent higher). Certain structural measures
13431 would provide benefits to adults migrating upstream. Overall abundance of returning adults
13432 may increase between 0 and 40 percent based on population and latent mortality assumptions.

13433 *Juvenile Fish Migration/Survival*

13434 This ESU migrates through the Snake and Columbia Rivers downstream past the eight CRS
13435 projects: four on the Snake River and four on the lower Columbia River. Structural and
13436 operational measures the Common Effects section that describe changes at all of these dams
13437 would affect these fish. The combination of several measures would, similar to the No Action
13438 Alternative, would be expected to decrease travel time and powerhouse encounters and overall
13439 increase juvenile outmigration survival, such as the *Additional Powerhouse Surface Passage*,
13440 *Upgrade to Adjustable Spillway Weirs*, and *Improved Fish Passage Turbines* measures. For Snake
13441 River spring/summer-run Chinook salmon, the COMPASS and CSS cohort models estimate that
13442 MO1 would increase juvenile survival from Lower Granite Dam to Bonneville Dam by less than 1
13443 percent, and travel time would decrease less than 2 percent. The structural measures and
13444 increase in spill during block periods would be expected to decrease powerhouse encounters
13445 somewhat, with the models predicting a relative decrease of about 16 to 19 percent. The
13446 *Predator Disruption Operations* measure, also described in Common Effects, would further
13447 increase juvenile survival by reducing predation on outmigrating smolts. TDG exposure would
13448 be less than 1 percent higher than the No Action Alternative, with a reach average exposure of
13449 115.1 percent TDG. See Table 3-75 for a list of model outputs related to juvenile migration and
13450 survival.

13451 **Table 3-75. Multiple Objective Alternative 1 Juvenile Model Metrics for Snake River**
13452 **Spring/Summer Chinook Salmon**

Metric (Model)	NAA	MO1	Change from NAA	% Change
Juvenile Survival (COMPASS)	50.4%	51.0%	+0.6%	+1%
Juvenile Survival (CSS)	57.6%	58.3%	+0.7%	+1%

Metric (Model)	NAA	MO1	Change from NAA	% Change
Juvenile Travel Time (COMPASS)	17.7 days	17.4 days	-0.3 days	-2%
Juvenile Travel Time (CSS)	15.8 days	15.5 days	-0.3 days	-2%
% Transported (COMPASS)	38.5%	37.8%	-0.7%	-2%
% Transported (CSS)	19.2%	26.5%	+7.3%	38%
Transport: In-River Benefit Ratio (CSS)	0.86	0.68	-0.18	-21%
Powerhouse Passages (COMPASS)	2.25	1.88	-0.37	-16%
Powerhouse Passages (CSS)	2.15	1.74	-0.41	-19%
TDG Average Exposure (TDG Tool)	115.1% TDG	115.5% TDG	+0.5% TDG	N/A

13453 Several measures in MO1 would affect juvenile Snake River spring/summer-run Chinook salmon
 13454 transportation rates. The NWFSC LCM predicted a negligible decrease in the overall proportion
 13455 of fish transported compared to the No Action Alternative, at about 38 percent of juveniles
 13456 transported. CSS, however, predicted an increase of 7.3 percent in transportation rate
 13457 compared to the CSS-modeled No Action Alternative. The CSS also predicted a lower total
 13458 transport rate with an absolute value of 26.5 percent of smolts transported under MO1, as well
 13459 as a decrease in the benefit to survival for transported smolts. The difference in modeled
 13460 transportation rates is likely due to the fact that the COMPASS model only uses natural origin
 13461 juveniles to assess transport rates while CSS includes hatchery fish as well.

13462 Smolts would be collected for transportation at the three Snake River collector projects starting
 13463 on April 15 under the *Early Start Transport* measure of MO1, which is earlier than the No Action
 13464 Alternative start date of April 25. The intent of this measure was to increase the region's
 13465 understanding of early season transport effects and to benefit early migrating Snake River
 13466 steelhead. With regard to Snake River spring/summer Chinook, the earlier start to juvenile fish
 13467 transport would have a neutral effect on the TIR, though hatchery origin Chinook salmon smolts
 13468 have a greater benefit of transportation during this timeframe than natural origin smolts
 13469 (Transport COP; Gosselin et al. 2018). However, because of the lower conversion rates
 13470 associated with fish that were transported as juveniles (Keefer et al. 2008; FPC memo 13-19),
 13471 without a clear benefit for the early period, earlier transport may slightly decrease Snake River
 13472 spring/summer-run Chinook salmon adult returns to spawning grounds.

13473 The increased spill in the high spill blocks associated with the *Block Spill Test (Base + 120/115%)*
 13474 measure, would also increase the number of juveniles passing via spillways and thus not able to
 13475 be collected in the juvenile fish bypasses for transportation. Reducing transport rates, especially
 13476 in May and June, would be expected to reduce SARs because those transported fish typically
 13477 have higher SARs than those of in-river migrants during this period.

13478 Across the entire spring migration season in both the No Action Alternative and MO1, the CSS
 13479 cohort model predicted lower return rates for juvenile Snake River Chinook that were
 13480 transported compared to fish that migrated in-river as juveniles. The benefit of transport in
 13481 MO1 was even less than the No Action Alternative and this difference is likely the result of
 13482 higher in-river SARs predicted by the CSS model under MO1.

13483 *Adult Fish Migration/Survival*

13484 Several structural measures in MO1 are anticipated to benefit adult Snake River spring/summer-
13485 run Chinook salmon passage upstream, including *Lower Granite Trap Modifications*, *Modify*
13486 *Bonneville Serpentine Weir* (reducing delay), and *Lower Snake Ladder Pumps* if there is cooler
13487 water available at depth. However, MO1 has block periods of higher spill under the *Block Spill*
13488 *Test (base + 120/115%)* measure, and fallback rates of Snake River spring/summer-run Chinook
13489 salmon may increase because fallback for this ESU has been associated with higher flow and
13490 higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). In recent years, adult
13491 passage delays have been observed at Little Goose Dam with spill levels over 30-35 percent. It is
13492 important to note that regional managers use in-season management techniques to identify and
13493 remedy any excessive fallback, which would likely mitigate for this increase in spill. Potential spill
13494 reduction starting during as early as August 1 using a spill trigger may reduce fallback for the few
13495 summer migrating adults that may still be migrating in August and no effects on spring migrating
13496 adults. However, while fallback rates may be lower, individuals that fell back would experience
13497 greater risk of falling back through turbines and juvenile bypass systems compared to spillways
13498 once the spill cessation trigger is met at individual lower Snake River projects.

13499 Increasing the reservoir operating range by 6 inches at the lower Snake River Dams (MOP 1.5-
13500 foot range) and at John Day Dam (MIP 2-foot range) would have little effect on flow, and thus is
13501 not expected to affect adult migration timing or survival rates (NMFS 2019). Similarly, holding
13502 contingency reserves within juvenile fish passage spill is likely to have little effect, if any, on
13503 adult migration.

13504 Finally, the modified Dworshak releases in MO1 were intended to provide cooler water during
13505 more targeted periods when the cooler water could make a difference for upstream migration
13506 conditions. However, the water quality effects analysis showed that this measure did not have
13507 the intended effect on cooling the lower Snake River corridor appreciably below 20°C during
13508 July and September in periods when water temperatures were otherwise above that threshold,
13509 and furthermore exacerbated warmwater temperatures in the August timeframe. This measure
13510 is unlikely to affect the few Snake River spring/summer-run Chinook salmon still migrating in
13511 the latter half of July.

13512 Table 3-76 displays the median model outputs for adult metrics from both NWFSC LCM and
13513 CSS. NWFSC LCM results include different scenarios of latent mortality in the ocean survival
13514 phase, including decreased mortality of 0 percent, 10 percent, 25 percent, and 50 percent
13515 (scenario indicated in parentheses).

13516 **Table 3-76. Multiple Objective Alternative 1 Adult Model Metrics for Snake River**
13517 **Spring/Summer-Run Chinook Salmon**

Metric (Model)	NAA	MO1	Change from NAA	% Change
LGR-BON SARs ^{1/} (NWFSC LCM) (Percent)	0.88%	0.88% (0%)	0 (0%)	0% (0%)
		0.93% (10%)	+0.05% (10%)	+6% (10%)
		1.00% (25%)	+0.12% (25%)	+14% (25%)
		1.12% (50%)	0.24% (50%)	+28% (50%)
SARs LGR-BON (CSS)	2.0%	2.2%	+0.2%	+10%

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Metric (Model)	NAA	MO1	Change from NAA	% Change
Abundance of Middle Fork, South Fork and upper Salmon River representative populations (Number of adults; NWFSC LCM) ^{2/}	2,351	2,411 (0%)	+60 (0%)	+3% (0%)
		2,563 (10%)	+212 (10%)	+9% (10%)
		2,826 (25%)	+475 (25%)	+20% (25%)
		3,290 (50%)	+939 (50%)	+40% (50%)
Abundance of Grande Ronde/Imnaha representative populations (CSS) ^{3/}	6,114	6,428	+314	+5%

13518 1/ NWFSC LCM does not factor latent mortality due to the Columbia River System into the SARS or abundance
13519 outputs. For discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent
13520 are shown. The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values
13521 represent scenarios of what SARs or abundance hypothetically could be under the increased ocean survival
13522 scenario if changes in the alternative were to decrease latent mortality by that much.

13523 2/ NWFSC LCM provided results for 16 populations in the upper Salmon River, South Fork Salmon River, and Middle
13524 Fork Salmon River major population groups. The absolute values include these populations only, the percent
13525 change is considered indicative of the Snake River ESU of spring-run Chinook salmon for the purpose of comparing
13526 between MOs.

13527 3/ CSS provided results for six populations in the Grande Ronde/Imnaha major population group. The absolute
13528 values represent those populations only; the percent change is considered indicative of the Snake River ESU of
13529 spring-run Chinook salmon for the purpose of comparing between MOs.

13530 The NWFSC LCM estimates SARs and abundance of the upper Salmon River, South Fork Salmon
13531 River, and Middle Fork Salmon River MPGs. CSS estimates the abundance of Grande
13532 Ronde/Imnaha MPG. Both models use a combination of hatchery and natural origin fish. For
13533 comparison purposes, the percent change from the No Action Alternative is considered
13534 indicative of the effects of MO1 on the Snake River spring-run Chinook salmon ESU.

13535 The NWFSC LCM predicts MO1 would result in a range from no change to a 28 percent relative
13536 increase in the smolt to return as adult rates to Bonneville Dam depending on the magnitude of
13537 latent mortality assumptions applied. The CSS model predicts a change of 0.2 percent increase
13538 (10 percent relative change) in survival of smolts from Lower Granite Dam to return as adults
13539 back to Bonneville Dam (from 2.0 percent in the No Action Alternative to 2.2 percent under
13540 MO1).

13541 With slight increases in juvenile survival both in the freshwater migration and in the ocean to
13542 adulthood, increases in abundance of fish to the spawning grounds would be expected. The
13543 NWFSC model, looking at the Middle Fork Salmon and South Fork Salmon MPGs, showed an
13544 average overall increase of about 3 percent without factoring in any change to latent mortality.
13545 The abundance change in individual populations would range from a 1 percent decrease (Big
13546 Creek population) to a 4 percent increase (Bear Valley Creek population). Smolts would
13547 experience fewer powerhouse routes, on average, that could potentially reduce latent
13548 mortality somewhat from the No Action Alternative and that could increase the adult returns
13549 more than indicated by the model. The CSS models, using the Grande Ronde/Imnaha MPG,
13550 indicated about 5 percent increase in abundance, with a range of from 5 percent to 12 percent
13551 increase in individual populations. With consideration of confidence of the models, this would
13552 indicate likely similar abundance.

13553 Qualitatively, MO1 would provide contrasting spill levels to test latent mortality effects under
13554 the *Block Spill Test (base + 120/115%)* measure, but would not likely change the overall
13555 expected latent mortality much because travel time, powerhouse encounters, and TDG
13556 exposure are similar to the No Action Alternative. The CSS models indicate ocean survival would
13557 be similar to the No Action Alternative. The NWFSC LCM SARS and abundance results with 0 to
13558 10 percent decreased latent mortality assumptions are similar to CSS results.

13559 Snake River Steelhead

13560 *Summary of Key Effects*

13561 Juvenile survival would be similar to the No Action Alternative, with models showing similar
13562 travel time and TDG exposure and lower powerhouse encounters, and predation may be
13563 decreased with the predator disruption measure. Structural measures and blocks of higher spill
13564 may increase kelt survival but warmer water temperatures in the Snake River would decrease
13565 it. The warmer August temperatures driven by operational changes at Dworshak would also
13566 reduce upstream migration survival and success. CSS modeled SARs predicted that returning
13567 adults to Bonneville may increase by up to 5 percent.

13568 *Juvenile Fish Migration/Survival*

13569 This DPS migrates through the Snake and Columbia Rivers downstream past the eight CRS
13570 projects, four on the Snake River, and four on the lower Columbia River. Structural and
13571 operational measures described in the Common Effects section that describe changes at these
13572 projects would apply to these fish. The combination of several measures would maintain overall
13573 travel time, reduce powerhouse encounters, and increase survival including the *Additional*
13574 *Powerhouse Surface Passage* measure at the McNary and John Day Projects, and the *Upgrade*
13575 *to Adjustable Spillway Weirs* measure at the McNary and John Day Projects. For Snake River
13576 steelhead, the COMPASS model predicts a decrease in juvenile survival of 0.5 percent, and CSS
13577 cohort models estimate that MO1 would increase juvenile survival from Lower Granite Dam to
13578 Bonneville Dam by 1.7 percent. Both models agree that travel time would be nearly the same
13579 and that powerhouse encounters would decrease 15 to 16 percent. The *Predator Disruption*
13580 *Operations* measure, also described in Common Effects, would further increase juvenile survival
13581 by reducing predation on outmigrating steelhead smolts. TDG exposure would be less than 1
13582 percent higher under the *Block Spill Test (Base +120/115%)* measure of MO1 than the No
13583 Action Alternative, with a reach average exposure of 115.1 percent TDG and little effect on
13584 juvenile survival. See Table 3-77 for a list of model outputs related to juvenile migration and
13585 survival.

13586 **Table 3-77. Juvenile Model Metrics for Snake River Steelhead under Multiple Objective**
13587 **Alternative 1**

Metric (Model)	NAA	MO1	Change from NAA	% Change
Juvenile Survival (COMPASS)	42.7%	42.2%	-0.5%	-1%
Juvenile Survival (CSS)	57.1%	58.8%	+1.7%	+3%
Juvenile Travel Time (COMPASS)	16.4 days	16.4 days	0 days	0%

Metric (Model)	NAA	MO1	Change from NAA	% Change
Juvenile Travel Time (CSS)	16.2 days	16.3 days	+0.1 days	+0%
% Transported (COMPASS)	39.7%	39.1%	-0.6%	-2%
% Transported (CSS)	Unknown			
Transport: In-River Benefit Ratio (CSS)	1.41	1.08	-0.33	-23%
Powerhouse Passages (COMPASS)	1.73	1.47	-0.26	-15%
Powerhouse Passages (CSS)	1.96	1.64	-0.32	-16%
TDG Average Exposure (TDG Tool)	115.1% TDG	115.5% TDG	+0.4% TDG	N/A

13588 Several measures in MO1, such as *Early Start Transport* affect juvenile Snake River steelhead
 13589 transportation rates, and season-wide, the CSS cohort model estimates a reduction in TIR (i.e.,
 13590 reduction in transport benefit, relative to migration in-river) of about 23 percent compared to
 13591 the TIR under the No Action Alternative. While a MO1 TIR of 1.08 represents a reduction in TIR
 13592 relative to the No Action Alternative (TIR 1.41), the TIR still represents a season-wide benefit to
 13593 steelhead that are transported relative to in-river migration, measured in terms of relative SARs
 13594 (DeHart CRSO-24/2019).

13595 The *Early Start Transport* measure would affect the change in transportation including an
 13596 earlier start to transport date (April 15) relative to the No Action Alternative start to transport
 13597 date of April 25. The earlier start to juvenile fish transport would likely increase adult returns
 13598 for hatchery origin steelhead and would have a neutral effect on natural origin steelhead. Thus,
 13599 the earlier transport date is likely not a driver of the TIR response relative to the No Action
 13600 Alternative because the effect should be beneficial or neutral, not adverse.

13601 The *Block Spill Test (Base + 120/115%)* measure would increase the number of juveniles passing
 13602 via spillways and thus would be unable to be collected in juvenile fish bypasses for
 13603 transportation. Reducing transport rates, especially in May and June, would be expected to
 13604 decrease total adult returns of steelhead. Higher MO1 in-river survival compared to the No
 13605 Action Alternative may also be a factor in the lower season-wide TIR in MO1 and is most likely
 13606 driver of the change in MO1 relative to the No Action Alternative. Overall, across the entire
 13607 spring migration season, the CSS cohort model estimated in-river migrants would return at a
 13608 lower rate than transported migrants under MO1 because the TIR was greater than 1 (average
 13609 TIR 1.08). This relative return rate of transported fish was less than the return rate of
 13610 transported fish for the No Action Alternative (TIR 1.41). However, TIR varies throughout the
 13611 season and so this overall TIR estimate does not provide information on the specific dates
 13612 within the season when transporting fish may yield higher or lower returns than the season
 13613 wide average.

13614 The COMPASS and CSS cohort model results support the qualitative expectations that the MO1
 13615 survival rates from the lower Snake River to below Bonneville Dam would be similar to the No
 13616 Action Alternative.

13617 *Adult Fish Migration/Survival*

13618 Several structural measures in MO1 are anticipated to benefit adult steelhead passage
13619 upstream, including *Lower Granite Trap Modifications* and *Modify Bonneville Ladder Serpentine*
13620 *Weir* (reducing delay), *Lower Snake Ladder Pumps*, if cooler water is present at depth in the
13621 forebays. Structural measures designed to increase juvenile survival (*Additional Powerhouse*
13622 *Surface Passage* and *Upgrade to Adjustable Spillway Weirs*) could also benefit kelt survival by
13623 increasing the proportion of downstream migrating kelts going through non-turbine routes.
13624 Higher spill periods of block spill could increase survival of kelts by increasing non-turbine
13625 routes. Warmer Snake River temperatures in August due to modified operations at Dworshak
13626 Dam would decrease steelhead upstream migration survival and success. Adult exposure to
13627 TDG would be similar to the No Action Alternative.

13628 Higher spill levels during April periods should result in higher survival rates for adult steelhead
13629 falling back through dams and kelts migrating downstream, as fewer adults used powerhouse
13630 passage routes when a spill route was available and overall downstream passage increased
13631 when surface passage was available (Normandeau et al. 2014).

13632 For Snake River steelhead, the CSS cohort model estimates that SARs would increase 5 percent
13633 from the No Action Alternative. Table 3-78 displays the CSS cohort model results for Snake
13634 River steelhead. NWFSC LCM modeling for Snake River steelhead was not available.

13635 **Table 3-78. Multiple Objective Alternative 1 Adult Model Metrics for Snake River Steelhead**

Metric (Model)	NAA	MO1	Change from NAA	% Change
SARs LGR-BON (CSS)	1.8%	1.9%	+0.1%	+5%

13636 Under MO1, fewer steelhead would be transported because of higher spill levels under the
13637 *Block Spill Test (Base + 120/115%)* measure. Based on observed data, without considering
13638 latent mortality, this is anticipated to result in a negligible change to return rates at Lower
13639 Granite Dam.

13640 Snake River Coho Salmon

13641 See Snake River spring/summer-run Chinook as a surrogate for juvenile Snake River coho
13642 salmon and Snake River fall-run Chinook as a qualitative surrogate for adult Snake River coho
13643 salmon.

13644 *Summary of Key Effects*

13645 Surrogate species modeling predicts a minor increase in survival in juvenile Snake River coho
13646 salmon. However, a survival increase for Snake River juvenile coho may be offset by an increase
13647 in water temperatures above 20°C that may be experienced by adult Snake River coho
13648 migrating through the lower Snake reach. This increase may increase delay, fallback, and
13649 susceptibility to disease by adults under MO1, compared to the No Action Alternative.

13650 *Juvenile Fish Migration/Survival*

13651 Based on Snake River surrogate species under MO1, juvenile survival of coho salmon would
13652 have minor increases in survival, minor reductions in travel times, and major reductions in
13653 powerhouse encounters, compared to the No Action Alternative. Refer to Snake River
13654 spring/summer-run Chinook as a surrogate for juvenile Snake River coho salmon for additional
13655 information.

13656 *Adult Fish Migration/Survival*

13657 For the lower Snake River reach, MO1 water quality modeling showed an increase in the
13658 frequency of water temperatures exceeding 20°C relative to the No Action Alternative. Adult
13659 Snake River coho salmon could experience a greater delay in their adult migration, increase in
13660 fallbacks at lower Snake River dams, and increase in susceptibility to disease compared to the
13661 No Action Alternative. Ultimately, increased (warmer) water temperatures would pose a
13662 greater risk to adult survival. This mechanism is described in more detail for *Snake River fall-run*
13663 *Chinook* (Section 3.5.3.3) as a surrogate for adult Snake River coho salmon.

13664 *Snake River Sockeye Salmon*

13665 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake
13666 River sockeye salmon.

13667 *Summary of Key Effects*

13668 Juvenile migration and survival would be similar or slightly better than the No Action
13669 Alternative with lower powerhouse encounter rates but similar travel time and TDG exposure.
13670 For adults, the most notable effect of MO1 is the increased risk of delay in upstream migration
13671 due to warmer river temperatures and increased temperature differential at the fish ladders.

13672 *Juvenile Fish Migration/Survival*

13673 This alternative is expected to result in a slightly faster migration time for juvenile Snake River
13674 sockeye salmon based on modeling results for juvenile Snake River Chinook salmon. Refer to
13675 the analysis of Snake River spring/summer-run Chinook salmon as a surrogate for Snake River
13676 sockeye salmon in Section 3.5.3.2. Juvenile sockeye salmon migrate faster than yearling
13677 Chinook, and it is assumed that slightly faster travel times would result in better survival due to
13678 less swimming effort and shorter duration of exposure to predators; the overall result is better
13679 survival rates. Along with the slightly faster travel time, modeled surrogate analyses predict
13680 that juvenile fish would also experience fewer powerhouse encounters relative to the No
13681 Action Alternative from MO1's *Additional Powerhouse Surface Passage, Upgrade to Adjustable*
13682 *Spillway Weirs, and Improved Fish Passage Turbines* measures, which may result in increased
13683 survival to adult returns.

13684 Increased block spill rates under MO1's *Block Spill Test (Base + 120/115%)* measure may
13685 contribute to the faster travel time, but the change in travel time due to spill rate is not a

13686 substantial difference. The mean water temperature during juvenile outmigration is expected
13687 to be the same as the No Action Alternative and would therefore have no difference in the risk
13688 of predation from other fish. Under the *Predator Disruption Operations* measure, the proposed
13689 operations at John Day Dam to increase the reservoir operating range could reduce nesting
13690 habitat for birds that eat salmon on the Blalock Islands, which would reduce mortality of
13691 juvenile sockeye salmon.

13692 Transportation of sockeye salmon could change due to spill and transportation measures in
13693 MO1, including the *Block Spill Test (Base + 120/115%)* and *Early Start Transport* measures. The
13694 outmigration window is more compressed, with the bulk of the smolts passing April through
13695 the end of May. However, starting transport earlier in April could increase transportation of
13696 juvenile sockeye salmon depending on the annual run-timing of downstream migrants.

13697 *Adult Fish Migration/Survival*

13698 Transport for sockeye as juveniles results in more fallback and longer migration time as adults,
13699 and more straying during upstream migration. Sockeye transported in the Snake River are more
13700 likely to fall back than in-river migrating fish (Crozier et al. 2015). Transportation of juveniles
13701 appears to impair adult homing ability (i.e., ability to return to their birth streams), which
13702 results in migration delay, increased fallback, and straying. This impaired homing ability may
13703 contribute to higher incidental harvest rates in the lower Columbia River than middle Columbia
13704 sockeye salmon, which are the targets of the fishery. This impaired homing ability can be lethal
13705 during warm water years such as 2015. MO1 may decrease transport, as described in the
13706 juvenile section, which could increase adult survival and migration success.

13707 The summer water temperatures in the river during the last week of sockeye migration would
13708 reduce migration success and survival of those fish; this represents a small portion of the run.
13709 The temperature differential between the river and the fish ladders would change under MO1.
13710 This alternative is estimated to have 65.5 percent of all days during the upstream migration
13711 period with a greater than 2 degree Celsius temperature difference between the river and the
13712 fish ladders compared to 50 percent of all days in the No Action Alternative. Experiencing
13713 substantially more days with a greater than 2 degree Celsius temperature differential between
13714 river water and the fish ladders would cause a greater risk of delay at the dams. Management
13715 of fish ladder temperatures has already been implemented at Little Goose and Lower Granite
13716 Dams, which were both identified as the top priority locations. Addition of ladder temperature
13717 management at Ice Harbor and lower Monumental Dams is part of MO1's *Lower Snake Ladder*
13718 *Pumps* measure.

13719 Important water quality parameters, such as TDG and its effects in the form of GBT would have
13720 no appreciable difference in MO1 from the No Action Alternative for either adults or juveniles.
13721 Likewise, there would be no change to sediment concentrations or DO levels from any
13722 measures in MO1.

13723 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for
13724 additional information on adult Snake River sockeye salmon in Section 3.5.3.2.

13725 Snake River Fall-Run Chinook Salmon

13726 *Summary of Key Effects*

13727 The most notable effect of MO1 is the increased risk of delay of adults migrating upstream at
13728 the fish ladders in late August due to water temperature differentials in the ladders.

13729 *Larval Development/Juvenile Rearing*

13730 None of the measures of MO1 would change the substrate sizes or distribution in the spawning
13731 areas or expand suitable spawning areas; therefore, this alternative is expected to have the
13732 same larval development and juvenile rearing habitat conditions as the No Action Alternative.
13733 The same is true for river depths in the spawning areas; no change is anticipated for eggs
13734 incubating in the gravel. Once juvenile Chinook salmon have emerged and moved to the
13735 reservoirs for rearing, lack of summer cooling water may reduce quality of rearing habitat for
13736 fish that hold over for their first year; however, the changes for MO1 would not be a
13737 measurable difference compared to the No Action Alternative.

13738 *Juvenile Fish Migration/Survival*

13739 In-river survival would be expected to be similar to the No Action Alternative because summer
13740 spill levels are the same. If spill levels were curtailed in August under this MO, the number of
13741 fish actively migrating through the Snake River are small enough that while there may be
13742 impacts to individual fish, there would not be a population level response expected.
13743 Transportation typically benefits Snake River juvenile fall Chinook in August, so any decreases in
13744 dam passage survival would likely be offset by increased returns from smolts that were
13745 transported downstream. Under MO1, there would be a slight reduction in risk of predation in
13746 May through July due to slightly reduced mean temperatures compared to the No Action
13747 Alternative. The mean temperature is expected to be 16.4°C, with 25.2 percent of days over
13748 20°C, which is a slight improvement from the No Action Alternative. Additionally, bird predation
13749 risk would decrease slightly due to changing operations at John Day Dam to reduce availability
13750 of bird nesting habitat under the *Predator Disruption Operations* measure. Effects would be
13751 more noticeable for species like spring Chinook salmon and steelhead that migrate earlier, but
13752 would still be effective for Snake River fall-run Chinook salmon. None of the measures in MO1
13753 would affect turbidity during the juvenile outmigration months of May through July; therefore,
13754 their visual cover from predation would not change.

13755 *Adult Fish Migration/Survival*

13756 Transport as juveniles results in more fallback and longer migration time as adults and more
13757 straying during upstream migration. Fish transported in the Snake River are more likely to fall
13758 back than in river fish (Bond et al. 2017). Under MO1, the portion of juveniles transported
13759 downstream would be approximately 38 percent compared to 39 percent in the No Action
13760 Alternative; therefore, the rate of fallback and straying by adult upstream migrants would likely
13761 remain the same.

13762 MO1 has a higher risk of delay and fallback because of changes to cooling water augmentation
13763 from Dworshak Dam under the *Modified Dworshak Summer Draft* measure. Temperatures at
13764 McNary Dam would have a slight increase, and temperatures at Ice Harbor Dam would have a
13765 pronounced increase with 62.7 percent of all days over 20°C compared to 54.3 percent in the
13766 No Action Alternative. Water temperatures delay adult migration during summer/fall when
13767 they exceed ~20°C. Increased adult straying is correlated with elevated temperatures. Warm
13768 water temperatures can also increase susceptibility to disease. All of these effects reduce
13769 survival and spawning success, including gamete viability.

13770 This alternative is estimated to have 65.5 percent of all days in August and September with a
13771 greater than 2 degree Celsius temperature difference between the river and the fish ladders
13772 compared to 50 percent of all days in the No Action Alternative; this is an additional 9 days
13773 during the migration period. The impact would be most noticeable during low-water/high-
13774 temperature years when there is less water available for cooling. Management of fish ladder
13775 temperatures has already been implemented at Little Goose and Lower Granite Dams, which
13776 were both identified as the top priority locations. Addition of ladder temperature management
13777 at Ice Harbor and lower Monumental Dams is part of MO1's *Lower Snake Ladder Pumps*
13778 measure.

13779 There would be no change to sediment concentrations or DO levels from the No Action
13780 Alternative as a result of any measures in MO1 during the adult migration period.

13781 ***Lower Columbia River Salmon and Steelhead***

13782 Lower Columbia River Chinook Salmon

13783 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower
13784 Columbia River Chinook salmon.

13785 *Summary of Key Effects*

13786 Juvenile survival and travel time would be similar to the No Action Alternative, with the
13787 possible exception that the fall run of Lower Columbia River Chinook salmon, which could
13788 experience slightly slower outmigration due to 4 to 5 percent lower flows in late summer. Adult
13789 migration and survival would be similar to the No Action Alternative, with potentially higher
13790 fallback during the higher spill block periods for the spring-run fish.

13791 The results (and change from the No Action Alternative) for metrics for lower Columbia River
13792 Chinook salmon follow:

- 13793 • Negligible increase in juvenile project survival at Bonneville Reservoir and Dam (see
13794 surrogate Snake River spring-run/summer-run Chinook salmon) = (+0.1 percent)
- 13795 • Bonneville Dam outflows, April to June = (-1 percent to -2 percent)
- 13796 • Bonneville Dam outflows, August to September = (-4 percent to -5 percent)

- 13797 • Spill, Bonneville Dam = April (+3 percent), May (+1 percent), August (-1 percent)
- 13798 • Temperature, The Dalles Dam, days exceeding state standard = 72 days (+1 day)
- 13799 • Temperature, Bonneville Dam, days exceeding state standard = 57 days (-1 day)
- 13800 • TDG, The Dalles Dam, days exceeding state standard = 29 days (+4 days)
- 13801 • TDG, Bonneville Dam, days exceeding state standard = 64 days (+3 days)

13802 *Juvenile Fish Migration/Survival*

13803 Five of the 32 populations of Lower Columbia River Chinook salmon pass Bonneville Dam on
13804 their downstream outmigration to the ocean. Modeling was not available for this ESU, so
13805 juvenile survival of Snake River spring-run/summer-run Chinook salmon at Bonneville Dam was
13806 used as a surrogate of juvenile survival. COMPASS modeling predicts juvenile survival to be
13807 similar in MO1 to the No Action Alternative. Refer to the Snake River spring/summer-run
13808 Chinook salmon analysis as a surrogate for additional information relevant to lower Columbia
13809 River Chinook salmon.

13810 Outflows can influence juvenile outmigration if changes in flows are enough to affect travel
13811 time and therefore survival. Hydrology modeling predicts spring-run and late-fall-run fish would
13812 experience outflows about one to two percent lower than the No Action Alternative. Fall-run
13813 fish outmigrate in late summer and may see flows up to 4 or 5 percent lower than the No
13814 Action Alternative. This slight decrease in late summer flows could affect the ability of these
13815 juveniles to outmigrate and use habitats in the estuary, but it would likely be imperceptible.
13816 Likewise, water quality modeling indicated there would not be a perceptible change in
13817 temperature nor TDG in the lower river with MO1 operations. MO1 includes the *Predator*
13818 *Disruption Operations* measure to reduce predation by reducing birds nesting in the John Day
13819 pool; this measure could decrease predation on the proportion of lower Columbia River
13820 Chinook salmon that migrate furthest upstream.

13821 *Adult Fish Migration/Survival*

13822 Structural measures such as the *Modify Bonneville Ladder Serpentine Weir* are expected to
13823 reduce delay associated with upstream passage. Fallback rates for spring-run may increase
13824 slightly with higher spill in April under MO1 as fallback is associated with higher flow and higher
13825 spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). However, regional managers
13826 use in-season adaptive management to identify and remedy any excessive fallback. Hydrology
13827 and water quality modeling predicts flows, temperatures, and TDG that could affect Lower
13828 Columbia River Chinook salmon adult migration and survival would all be similar to the No
13829 Action Alternative. Slightly lower outflows in August could affect migration success for fall-run
13830 fish.

13831 Lower Columbia River Steelhead

13832 Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

13833 *Summary of Key Effects*

13834 Juvenile survival and travel time would be similar to the No Action Alternative, with similar
13835 modeled dam survival, hydrology, and water quality metrics and a potential increase in survival
13836 due to predation disruption. Adult migration and survival would be similar to the No Action
13837 Alternative, with potentially higher fallback during the higher spill block periods for the spring-
13838 run fish.

13839 The results (and change from the No Action Alternative) for metrics for Lower Columbia River
13840 steelhead follow:

- 13841 • Negligible decrease in juvenile project survival, Bonneville Reservoir and Dam (see Snake
13842 River steelhead [used as a surrogate]) = (-0.3 percent)
- 13843 • Bonneville Dam outflows, March to June = (-1 percent to -2 percent)
- 13844 • Bonneville Dam outflows, August to September (-4 percent to -5 percent), otherwise (-1
13845 percent to +2 percent)
- 13846 • Spill, Bonneville Dam = April (+3 percent), May (+1 percent), August (-1 percent)
- 13847 • Temperature, The Dalles Dam, days exceeding state standard = 72 days (+1 day)
- 13848 • Temperature, Bonneville Dam, days exceeding state standard = 57 days (-1 day)
- 13849 • TDG, The Dalles Dam, days exceeding state standard = 29 days (+4 days)
- 13850 • TDG, Bonneville Dam, days exceeding state standard = 64 days (+3 days)

13851 *Juvenile Fish Migration/Survival*

13852 Four of the 23 populations of Lower Columbia River steelhead pass Bonneville Dam on their
13853 downstream outmigration to the ocean. Modeling was not available for Lower Columbia River
13854 steelhead, so juvenile survival of Snake River steelhead was used as a surrogate of juvenile
13855 survival through the Bonneville project (pool and dam) for this portion of the DPS. COMPASS
13856 modeling predicts a negligible decrease in juvenile survival as compared to the No Action
13857 Alternative. Outflows and temperatures would be similar to the No Action Alternative, within 1
13858 or 2 percent, which would likely not affect juvenile outmigration noticeably. TDG would be
13859 slightly higher from the *Block Spill Test (Base + 120/115%)* measure and may influence survival
13860 slightly. A decrease in survival of only 0.5 percent was predicted due to higher TDG for Snake
13861 River steelhead, which experience a much longer migration through eight projects instead of
13862 one for Lower Columbia River steelhead. Any change to Lower Columbia River steelhead with
13863 shorter migrations and fewer projects passed would be imperceptible. The *Predator Disruption*
13864 *Operations* measure, as described in the Common Effects section, would reduce predation on
13865 outmigration Lower Columbia River steelhead smolts.

13866 *Adult Fish Migration/Survival*

13867 Structural measures, such as the *Modify Bonneville Ladder Serpentine Weir* measure, are
13868 expected to reduce delay associated with upstream passage under MO1. April spill at
13869 Bonneville Dam under the *Block Spill Test (Base + 120/115%)* measure would be 3 percent
13870 higher than the No Action Alternative that could result in slightly higher survival rates for adult
13871 steelhead falling back through dams and kelts migrating downstream. Fewer adults used
13872 powerhouse passage routes when a spill route was available and overall downstream passage
13873 increased when surface passage was available (Normandeau et al. 2014). Kelts that pass via
13874 surface passage at Bonneville Dam experience 100 percent survival (Rayamajhi et al. 2012).
13875 Most hydrology and water quality metrics predict flows, and temperatures that could affect
13876 Lower Columbia River steelhead adult migration, and survival would be similar to the No Action
13877 Alternative. Slightly higher TDG exposure could affect adult survival, and lower (4 to 5 percent)
13878 outflows in August could affect migration success for summer-run fish.

13879 Lower Columbia River Coho Salmon

13880 See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower
13881 Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult
13882 Lower Columbia River coho salmon.

13883 *Summary of Key Effects*

13884 Overall, no change or negligible changes would occur for lower Columbia River coho salmon
13885 under MO1 due to passage and water temperatures, relative to the No Action Alternative.

13886 *Juvenile Fish Migration/Survival*

13887 Using the surrogate approach, CRS operational changes in MO1 would not change survival rates
13888 for Lower Columbia River juvenile coho salmon passing Bonneville Reservoir and Dam. Based on
13889 dam-specific COMPASS modeling for Snake River spring-run Chinook juveniles—used as a
13890 surrogate species for Lower Columbia River coho juveniles—passage success through the
13891 Bonneville project could decline by a fraction of a percent (approximately 0.2 percent). Refer to
13892 Snake River spring-run Chinook for surrogate information in Section 3.5.2.3.

13893 *Adult Fish Migration/Survival*

13894 Based on analysis of modeling results, water temperatures around Bonneville Dam specifically
13895 may be slightly cooler under all of the MOs compared to the No Action Alternative. Under MO1,
13896 the river temperatures near Bonneville Dam that exceed 20°C would occur primarily in August
13897 during the early weeks of adult migration and would be similar to the No Action Alternative.
13898 Refer to Snake River fall-run Chinook for qualitative surrogate information in Section 3.5.2.3.

13899 Columbia River Chum Salmon

13900 Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia
13901 River chum salmon.

13902 *Summary of Key Effects*

13903 MO1 would be similar to the No Action Alternative for chum salmon, with about a 2 percent
13904 increase, compared to the No Action Alternative, of years where the flows could not be met
13905 without additional drafting of Grand Coulee Dam (additional 2 out of 80 years). Juvenile
13906 outmigration could be slightly slower due to decreased outflows in March, and a negligible
13907 proportion that pass Bonneville Dam would experience decreased survival at that project. Adult
13908 migration and survival would likely be similar to the No Action Alternative. These would be
13909 negligible effects to chum salmon.

13910 *Larval Development/Juvenile Rearing*

13911 How operations under MO1 affects the ability of Grand Coulee Dam to provide winter flows to
13912 protect chum redds below Bonneville Dam and provide sufficient access to habitat was
13913 calculated using hydrology modeling. Under MO1, chum flows would be met in 90 percent of
13914 years, compared to 92 percent of years in the No Action Alternative. In years when additional
13915 releases from Grand Coulee for chum would be needed, the average additional volume needed
13916 would be 0.13 Maf. MO1 would result in 2 percent more years where chum flows would not be
13917 met, and decision-makers would have to decide whether to increase risk to chum eggs or
13918 reduce spring augmentation flows for spring migrating juvenile salmon.

13919 Maintaining water saturation of 105 percent TDG or less from November 1 to April 30 appears
13920 to provide a sufficient level of protection to chum salmon eggs and sac fry incubating in the
13921 gravel downstream of Bonneville Dam in the Ives/Pierce Island Complex. In MO1 under the
13922 *Block Spill Test (Base + 120/115%)* measure, chum sac fry would be exposed to TDG above 105
13923 percent in 7 out of 80 years, and those exceedances are all in the mid-late April timeframe. This
13924 is two more years than in the No Action Alternative.

13925 *Juvenile Fish Migration/Survival*

13926 Chum salmon encounter only one CRS project, Bonneville Dam, so none of the structural measures
13927 described in common effects for juvenile salmon and steelhead would apply to these fish, and only
13928 a small proportion of spawning occurs above Bonneville. As there is no direct estimate of
13929 Bonneville Dam survival specific to juvenile chum, juvenile model metrics for Snake River spring-
13930 run/summer-run Chinook salmon are used as a surrogate to estimate any change in juvenile
13931 survival for the portion that pass Bonneville Dam. Under MO1, COMPASS modeling of the
13932 surrogate species indicates that MO1 would be similar to the No Action Alternative.

13933 *Adult Fish Migration/Survival*

13934 The structural measure, *Modify Bonneville Ladder Serpentine Weir*, would improve passage for
13935 the portion of chum that pass this project, but most chum spawn downstream of Bonneville
13936 Dam. Migration of chum into the Columbia River is in October and November. Bonneville Dam
13937 average monthly outflows would be the same as the No Action Alternative in these months and
13938 about 2 percent higher in December under MO1.

13939 **Other Anadromous Fish**

13940 *Pacific Eulachon*

13941 *Summary of Key Effects*

13942 Effects of MO1 would be similar to the No Action Alternative for juvenile eulachon migration
13943 and survival.

13944 Compared to the No Action Alternative, MO1 would have no change in the time between the
13945 peak spawning runs, egg development, and larval emergence. The spring freshet that disperses
13946 larvae to adequate food sources would continue to be highly variable, with an average of 168
13947 days between spawning temperature triggers and peak flows (158 days in high-flow years, and
13948 156 days in low-flow years).

13949 Spring flow rates would be expected to be about 1 to 2 percent lower during outmigration
13950 compared to the No Action Alternative, so any changes affecting eulachon feeding would be
13951 negligible.

13952 Eulachon would continue to migrate into the Columbia River from November through March,
13953 with specific dates of migration and spawning based on a variety of environmental factors,
13954 including temperature, high tides, and ocean conditions (NMFS 2017). Modeled data for MO1
13955 (based on the period of record for Bonneville Dam tailwater temperatures) indicate that
13956 temperatures would not be substantially different from the No Action Alternative (all
13957 temperatures would be within 0.6 degree Celsius of the No Action Alternative). Spawning
13958 locations and substrate conditions would not be expected to differ from the No Action
13959 Alternative. Although migration as far upstream as Bonneville Dam is unusual, structural
13960 measures at the fish ladders could make passage easier for eulachon.

13961 Bird predation risk can be influenced by flow rates. Higher flows are linked to higher predation
13962 rates on eulachon, whereas at lower flows, birds tend to switch to marine prey. Under MO1,
13963 there would be negligible change (0 to 3 percent) in survival rates due to predation across all
13964 months and water year types.

13965 **Green Sturgeon**

13966 *Summary of Key Effects*

13967 The Columbia River use by green sturgeon is primarily foraging habitat for adults and subadults.
13968 Key effects of MO1 are focused on how flows and temperatures influence the cues for entering
13969 the Columbia River as well as the availability and distribution of food sources. Overall, the lower
13970 Columbia River would continue to provide good foraging and rearing habitat for green
13971 sturgeon, with negligible decreases in summer foraging habitat from flows that would be 4 to 5
13972 percent lower than the No Action Alternative in August.

13973 **Pacific Lamprey**

13974 Summary of Key Effects

13975 MO1 has several measures that are designed specifically to benefit lamprey: *Lamprey Passage*
13976 *Structures, Turbine Strainer Lamprey Exclusion, Bypass Screen Modifications for Lamprey, and*
13977 *Lamprey Passage Ladder Modifications*. These measures are proposed structural improvements
13978 that include converting extended-length submersible bar screens to submersible bar screens,
13979 expanding the network of lamprey passage structures to bypass impediments in fish ladders,
13980 changing the design for turbine cooling water strainers, and replacing turbines for safer fish
13981 passage, among other physical modifications to reduce fish injury and mortality.

13982 As described for the No Action Alternative, upstream and downstream passage at the mainstem
13983 Columbia River and Snake River Dams has been the greatest influence on population decline
13984 and reduced distribution of Pacific lamprey. The most substantial benefit of MO1 would be the
13985 improvements to get fish to enter the fish ladders; this would occur through expanding the
13986 network of lamprey passage structures and modifying fish ladders to incorporate lamprey
13987 passage criteria into the structural modifications.

13988 Larval Development/Juvenile Rearing

13989 MO1 includes manipulation of the John Day Reservoir for predator disruption under the
13990 *Predator Disruption Operations* measure. Water levels would be increased during nesting
13991 season and then dropped back down to the normal operating pool. Depending on dewatering
13992 rates, larval lamprey could become stranded if they are rearing in the shallows when the pool
13993 level would be dropped. Otherwise, ramping rates and dewatering issues would be the same in
13994 this alternative as for the No Action Alternative.

13995 Juvenile Fish Migration/Survival

13996 Water temperatures and physical structures affect juvenile lamprey during their outmigration.
13997 The *Modified Dworshak Summer Draft* measure would cause changes in temperature
13998 downstream in the lower Snake River compared to the No Action Alternative. At Lower Granite
13999 Dam, temperatures would be cooler June to August 1, warmer early August to mid-September,
14000 and cooler in mid-September to October. Temperatures could increase up to 4 degrees

14001 Fahrenheit with rapid fluctuation to about 3 degrees Fahrenheit cooler in about a week. Lower
14002 Granite Dam results in several days warmer than 20°C compared to none in the No Action
14003 Alternative which would be a minor adverse effect. The effect continues downstream and
14004 would be attenuated with distance from Dworshak Dam. The lower Columbia River
14005 temperatures would be similar to the No Action Alternative. Compared to the No Action
14006 Alternative, the number of days exceeding the state temperature standards in the lower Snake
14007 River would be as follows:

- 14008 • Lower Granite Dam: 22.6 days (18.2 more than the No Action Alternative)
- 14009 • Little Goose Dam: 45.6 (8.6 more than the No Action Alternative)
- 14010 • Lower Monumental Dam: 54.4 (7.2 more than the No Action Alternative)

14011 Several measures would improve conditions for outmigrating juveniles. Proposed actions
14012 include the following:

- 14013 • *Bypass Screen Modifications for Lamprey* measure: Converting the extended-length
14014 submersible bar screens to submerged traveling screens would substantially reduce
14015 mortality due to lamprey being trapped against intake screens (i.e., impingement). Because
14016 turbine routes are generally associated with lower survival of migrating juvenile salmon and
14017 steelhead, they are equipped screens that help bypass these fish to higher survival routes.
14018 Some of these screens are made of closely spaced bars rather than a mesh material. These
14019 screens are effective at diverting juvenile salmon and steelhead, but juvenile lamprey are
14020 often so small they become impinged between these bars. The modification or replacement
14021 of these screens with woven mesh or more tightly spaced bar material would reduce
14022 lamprey mortality by an unknown amount.
- 14023 • *Turbine Strainer Lamprey Exclusion* measure: A new design of structure for exclusion of
14024 juvenile lamprey from cooling water strainer intakes would substantially reduce or
14025 eliminate this pathway of mortality. Turbine cooling water intakes within the turbine scroll
14026 case are equipped with a strainer that prevents debris from entering the cooling water
14027 system. However, these strainers do not prevent the entrainment of juvenile lamprey and
14028 some juvenile salmon and steelhead. An unknown number of these fish are entrained and
14029 die in the cooling system each year. The retrofitting of these intakes with hoods that allow
14030 water flow but prevent debris and juvenile fish entry would reduce lamprey losses in the
14031 cooling water intake system.
- 14032 • *Additional Powerhouse Surface Passage* measure: Additional powerhouse surface passage
14033 at Ice Harbor and McNary Projects (described in the Common Effects to Salmon and
14034 Steelhead section) could change the dynamics of lamprey passage. Lamprey migrate fairly
14035 deep in the water column and most pass the dams via the powerhouse, however a slightly
14036 higher percentage of lamprey would be expected to pass via the surface routes instead of
14037 the turbines in relation to the No Action Alternative, although the relative effect on lamprey
14038 is not known.
- 14039 • *Improved Fish Passage Turbines* measure: Replacing turbines at the John Day Project (also
14040 defined in the Common Effects to Salmon and Steelhead section) with a newer design of
14041 turbine would improve conditions for fish passage and reduce the injury rate for lamprey.

14042 Because of the high degree of uncertainty surrounding how many juvenile lamprey are lost or
14043 injured on their downstream migration, and the relative effects to juvenile lamprey due to
14044 passage via surface routes or turbine routes, it is difficult to quantify the improvement
14045 represented by all of the measures. For fish that encounter multiple dams on their migration
14046 downstream, reducing the total number of hazards would increase their probability for survival
14047 to the adult life stage.

14048 Adult Migration/Survival

14049 Structural measures in MO1 that were intended to provide improvements to adult lamprey
14050 passage and survival include:

- 14051 • *Lamprey Passage Structures and Lamprey Passage Ladder Modifications* measures at
14052 Bonneville, The Dalles, and John Day Projects: Fish ladders at most of the projects were
14053 designed primarily for salmon and steelhead passage. More recent work has shown some
14054 parts of the structures create migration delays and even barriers for lamprey.
- 14055 • *Modify Bonneville Ladder Serpentine Weir* measure: At Bonneville Dam's Bradford Island
14056 and Washington Shore ladder flow control sections, the baffles that help slow velocities and
14057 control flows do not allow for direct line movement of fish passing the dam, but requires
14058 fish to weave through the baffles. This construction reduces fish passage efficiency and
14059 increases migration delays. The modification of these baffles would include replacing baffles
14060 allow for direct faster movement through the ladder baffles from this section of the ladders
14061 and replace them with baffles that have in-line vertical slots and orifices. This measure has
14062 the potential to increase adult salmon and steelhead survival by reducing upstream travel
14063 times and higher conversion rates. A similar modification at John Day Dam, the only other
14064 CRS dam to use this type of ladder, resulted in major passage time reductions for salmon
14065 and steelhead. Similar improvements are expected for Bonneville Dam. In addition, these
14066 improvements would reduce migration delays and barriers for Pacific lamprey.

14067 Each structural measure in MO1 that targets lamprey is intended to increase their dam passage
14068 efficiency either by getting fish to enter rather than turn back from the fishway, or to increase
14069 successful passage to the upstream end to continue migrating. Effectiveness of the measure
14070 would vary by dam. At Bonneville Dam, the measures that aid in getting adult fish into the
14071 fishways would be a substantial improvement over the existing conditions of only 44 to 50
14072 percent of lamprey entering the fishways. If the structural measures were successful at Bonneville
14073 Dam, the action agencies expect an improvement to approximately 70 percent of lamprey
14074 entering the fishways. Additionally, the *Modify Bonneville Ladder Serpentine Weir* measure would
14075 substantially improve upstream passage efficiency for lamprey at Bonneville Dam. Lamprey
14076 passage structures would likely represent more overall benefit than ladder improvements
14077 because the lampreys do not make it into the structures at Bradford Island fishway.
14078 Improvements at John Day Dam ladders to improve lamprey entrance into the fishway resulted in
14079 increased efficiency of 46 percent to 83 percent. Dynamics at each dam are very different, so the
14080 action agencies cannot infer directly across projects, but lamprey do see improvements in overall
14081 dam passage efficiency with improvements in ladder entrance efficiency.

14082 The Dalles Dam has relatively good lamprey passage, so the increment of improvement would
14083 be helpful, but not as great as what is expected at Bonneville Dam. At John Day Dam, lamprey
14084 passage is about 60 to 70 percent; additional work for the lamprey passage structures on the
14085 south and extension on the north would continue to moderately improve overall dam passage
14086 efficiency incrementally. Other measures to improve fish passage include the following:

- 14087 • The *Lower Granite Trap Modifications* measure would improve lamprey passage issues at
14088 the adult trap by allowing lamprey to pass when scientists are not trapping fish. This
14089 measure is described in detail in the Common Effects to Salmon and Steelhead section.
- 14090 • The *Lower Snake Ladder Pumps* measure at Lower Monumental and Ice Harbor Dams would
14091 be expected to benefit lamprey because this has been successful at Little Goose and Ice
14092 Harbor Dams. This measure is described in detail in the Common Effects to Salmon and
14093 Steelhead section.
- 14094 • The *Lamprey Passage Ladder Modifications* measure would involve modifications to The
14095 Lower Monumental Project that include diffuser grate plating. This action has been
14096 completed at all other ladders except Lower Monumental Dam and has demonstrated slight
14097 benefits to lamprey passage.

14098 The overall expected improvements in lamprey passage efficiency should decrease
14099 susceptibility to physical stress and mortality, and shorter holding time is beneficial to the fish.
14100 These structural measures for lamprey are expected to provide a substantial benefit to the
14101 distribution of Pacific lamprey in the Columbia Basin. All of the structural measures to reduce
14102 losses would have benefits to the population and recruitment in the next generation. Pacific
14103 Lamprey do not exhibit strong homing tendencies to their river of natal origin, hence, improved
14104 survival rates from adult return to juvenile outmigration would benefit the north Pacific
14105 population rather than only the Columbia Basin.

14106 ***American Shad***

14107 Summary of Key Effects

14108 No change is anticipated to juvenile shad because plankton communities and shoreline habitat
14109 are not changing in MO1. The proportion of adult shad counted at Bonneville Dam that migrate
14110 upstream past McNary Dam is expected remain similar under this alternative.

14111 **RESIDENT FISH**

14112 **Region A**

14113 ***Kootenai River Basin***

14114 Summary of Key Effects

14115 MO1 would have the same key effects as the No Action Alternative. Spring water temperatures
14116 would continue to be too cold for the development of many of these aquatic species. Spring

14117 flows would also continue to increase at an unnaturally low rate, thereby delaying and reducing
14118 productivity associated with inundated riparian and varial zone habitats in the river corridor
14119 from the dam to Kootenay Lake in British Columbia. These reduced flow rates would also
14120 continue to limit productivity and may adversely impact kokanee and their food sources
14121 downstream of Libby Dam.

14122 Under MO1, fluctuations in discharge from Libby Dam in the winter from the *December Libby*
14123 *Target Elevation* measure would continue to adversely affect benthic organisms. Cottonwood
14124 seedlings would continue to have variable survival depending on timing, stage and duration of
14125 spring flows, along with winter stage during the ensuing winter. In addition, the discharge
14126 regime from Libby Dam would not provide for successful burbot recruitment, and spring water
14127 temperatures would be too cold to allow for proper larval development.

14128 Habitat Effects Common to All Fish

14129 MO1's *Modified Draft at Libby* measure would also have a lower rate of flow increase from
14130 Libby Dam between mid-April and mid-May than the No Action Alternative. This decrease in
14131 flow rate combined with more cold water on wet years could result in later warming that would
14132 translate to a greater delay in growth and development of resident fish and their food
14133 resources.

14134 MO1's *Modified Draft at Libby*, *December Libby Target Elevation*, and *Sliding Scale at Libby and*
14135 *Hungry Horse* measures would increase slightly the potential and area for cottonwood and
14136 willow seeding and recruitment compared to the No Action Alternative. Under MO1 there
14137 would be a slight increase in the number of days when winter peak stages would not exceed
14138 the water levels needed for cottonwood and willow seeding at Bonners Ferry.

14139 Bull Trout

14140 Under MO1, Lake Koocanusa would be above elevation 2,450 feet for seven more days on
14141 average (15 percent) than the No Action Alternative during the summer when productivity is
14142 critical. The expected result would be slightly higher productivity and improved food availability
14143 than under the No Action Alternative.

14144 The average minimum annual pool elevation of Lake Koocanusa under MO1 would be
14145 approximately 2 feet lower in dry and average years than under the No Action Alternative. The
14146 expected result would be more frequent annual dewatering and decreased benthic insect
14147 production, which may result in a decrease in bull trout growth and/or survival. The annual
14148 maximum elevation of Lake Koocanusa under MO1 would be higher as shown by the 1.6-foot
14149 higher median July 31 elevation than under the No Action Alternative and may result in slightly
14150 higher terrestrial insect deposition under this alternative.

14151 Water temperature in Lake Koocanusa under MO1 would not be substantially different from
14152 that under the No Action Alternative. However, under MO1, the higher winter pool elevations
14153 in wet years associated with flood risk management and power generation could result in a

14154 colder thermal mass that warms slowly. In dry years, lower pool elevations would result in quick
14155 springtime warming of the forebay, and thus warmer discharge temperatures during the spring
14156 and summer when compared to the No Action Alternative.

14157 Under MO1, Libby Dam would provide discharge of 20 kcfs or greater for 12 days, on average,
14158 during the spring freshet, which is one day less than mean for the No Action Alternative. The
14159 mean flow rate from May 15 to June 15 under MO1 would be slightly less than under the No
14160 Action Alternative and would be insufficient to mobilize or reshape tributary deltas that can
14161 prevent bull trout access during low flows in the fall spawning season.

14162 While MO1 would have somewhat lower discharges from Libby Dam than the No Action
14163 Alternative, these reduced flows would provide slightly more usable habitat.

14164 Kootenai River White Sturgeon

14165 Effects of MO1 would not be different from those of the No Action Alternative for Kootenai
14166 River White Sturgeon.

14167 Other Fish

14168 The minimum annual pool elevation of Lake Kooconusa under MO1 would be approximately 2
14169 feet lower in dry and average years than under the No Action Alternative. This would result in
14170 reductions in insect larvae production and food available for resident fish species, which may
14171 decrease growth and survival of these species. However, in wet years, MO1 would provide a
14172 shallower draft and may be more beneficial to benthic insect production during those years.
14173 The annual maximum elevation of Lake Kooconusa under MO1 would be higher than under the
14174 No Action Alternative as shown by the 1.6-foot higher median July 31 elevation and may result
14175 in slightly higher terrestrial insect deposition. Under MO1, higher pool elevation in the early
14176 winter followed by aggressive drafting (higher outflows) associated with flood risk management
14177 and power generation could result in a warmer winter flows and colder early spring flows than
14178 the No Action Alternative. The 75th percentile elevation is slightly higher than the No Action
14179 Alternative and this larger cold thermal mass warms slightly slower. On dry years, a lower pool
14180 elevation would result in quicker springtime warming of the forebay, and thus warmer
14181 discharge temperature during spring and early summer.

14182 MO1 would have slightly lower discharges from Libby Dam for the period May 15 to September
14183 30 than the No Action Alternative and would provide slightly more usable habitat for juvenile
14184 and adult rainbow trout than the No Action Alternative. High and variable flows can interrupt
14185 burbot spawning migrations, while low (4 kcfs) and stable winter flows encourage successful
14186 burbot spawning. Median flows under MO1 as measured at Bonners Ferry would be higher
14187 than No Action Alternative flows in January through April and would be less likely to provide
14188 conditions conducive to successful burbot recruitment.

14189 ***Hungry Horse/Flathead/Clark Fork Fish Communities***

14190 Summary of Key Effects

14191 The key effects of MO1 are largely biological responses to changes in Hungry Horse Reservoir
14192 elevations and outflows to provide additional water supply under the *Hungry Horse Additional*
14193 *Water Supply* and *Sliding Scale at Libby and Hungry Horse* measures. Lower elevations through
14194 the summer decrease food supply for fish with slight reductions in plankton production and
14195 surface area for summer terrestrial insects. Benthic insect production important to fish would
14196 be appreciably decreased under MO1. Lower surface elevations could also increase issues with
14197 predation/exploitation risk as fish migrate into and out of tributaries to fulfill their life cycles,
14198 and increased outflows in summer would likely result in increased entrainment of zooplankton
14199 and fish out of Hungry Horse reservoir. Increased flows in the South Fork Flathead River would
14200 be attenuated with flows from the mainstem Flathead River but would still result in higher
14201 summer flows that would increase velocities. These velocity increases could decrease native
14202 fish habitat suitability in that reach. MO1 would have negligible effects on Flathead Lake, lower
14203 Flathead River, or Clark Fork fish.

14204 Habitat Effects Common to All Fish

14205 In wet and average water years the reservoir would still reach near full pool (elevation 3,560
14206 feet) by early July in most average years and mid-July in wet years. However, in these year
14207 types the median elevation at the end of September would be 3,546 feet, or about four to five
14208 feet lower than the No Action Alternative. In dry years the reservoir would still approach full
14209 pool, miss filling and typically become drawn down faster in the same pattern as the No Action
14210 Alternative, but the dry year elevation would be a median of a foot lower than the No Action
14211 Alternative dry year. All year types considered, there would be a 69 percent annual probability
14212 of reaching elevation 3,559 feet by July 31, or six years more out of 100 that would not reach
14213 full compared to the No Action Alternative. In extreme years, MO1 could be up to 11 feet lower
14214 than No Action Alternative by the end of September. In fall and winter months, MO1 would be
14215 lower than No Action Alternative. The fall and winter elevations would follow the same pattern
14216 as modeled, but the difference between No Action Alternative and MO1 would only be up to six
14217 or seven feet lower than No Action Alternative. The rate of drop would at times be steeper than
14218 No Action Alternative through these months.

14219 Lake elevation in the warm summer months determines the volume of reservoir that would be
14220 available to produce plankton (euphotic zone). With lower summer elevations, the euphotic
14221 zone decreases slightly under MO1. In June, MO1 and No Action Alternative are similar, but by
14222 July they begin to diverge with MO1 zone becoming less than the No Action Alternative. By
14223 September under MO1, the euphotic zone is about 32,000 acre-feet smaller than the No Action
14224 Alternative in wet and average years, and about 11,500 acre-feet smaller in dry years. The
14225 decrease ranges from one to three percent of the total volume. See Appendix E for a table of
14226 the calculated euphotic zone predictions under MO1.

14227 Drawdowns any time during the year affect the production of insects that live on the bottom of
14228 the reservoir. As reservoir elevations drop, insects that have established in this zone can
14229 become dewatered. The insect eggs would have been deposited within the euphotic zone
14230 described above. If reservoir levels drop, that zone remains the same thickness and drops with
14231 the surface level, but there would be no insects deposited at the lower elevation that is now
14232 the euphotic zone. As the elevation drops, the surface for benthic insect production gets
14233 smaller. MO1 drops faster than the No Action Alternative in the summer and would be at lower
14234 elevation through the following fall and winter. This would result in less area for benthic insect
14235 production than the No Action Alternative. Some of the larger aquatic insects have long life
14236 cycles that require overwintering where they were deposited; lower winter elevations would
14237 reduce the survival of these important insects. Table 3-62 shows size of the lake (surface area in
14238 acres) at the end of each month. Using surface area as an index for benthic area, MO1 surface
14239 area would decrease by 200 to 800 acres compared to the No Action Alternative, or about 2 to
14240 4 percent from October through February in all year types, and in dry and average years March
14241 through May would have similar decreases. Additionally, in dry years the summer months
14242 would have surface area 4 percent to 5 percent lower than the No Action Alternative, or a
14243 difference of about 530 to 820 acres. The large bays at the upper end of the reservoir could
14244 experience a proportionally higher rate of dewatering with dropping levels over the summer
14245 due to more shallow slopes. An equal drop in elevation would result in a larger dewatered
14246 benthic surface area, therefore actual lost benthic production would be more than surface area
14247 indicates, and considerable mortality of established benthic macroinvertebrates would be
14248 expected.

14249 Finally, the reservoir elevation determines the surface area available for terrestrial insects to
14250 land on the water and be available for fish food in summer, as well as influencing the proximity
14251 of the water's edge to terrestrial vegetation. Therefore, the availability of some important
14252 insects to fish through the winter months the reservoir surface would be about 300 to 800
14253 acres smaller, or 2 to 4 percent smaller compared to the No Action Alternative. In summer
14254 months as the elevation decreases faster under MO1 the surface area would be about 100 to
14255 400 acres smaller, or 1 to 2 percent smaller than under the No Action Alternative by the end of
14256 summer.

14257 Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry
14258 Horse reservoir. The zooplankton enhances food supply in the South Fork Flathead River and
14259 along the near bank of the Flathead River but decreases food supply for fish in Hungry Horse
14260 Reservoir. Outflows, and therefore zooplankton entrainment, under MO1 would be higher in
14261 summer and lower in fall, winter, and spring. These zooplankton are concentrated in the
14262 withdrawal zone in summer so the entrainment effect from increased summer outflows would
14263 be disproportionate; the 9 percent to 21 percent higher flows would likely represent a higher
14264 increase in zooplankton entrainment.

14265 Outflow patterns from Hungry Horse Reservoir can also affect how fish are entrained into the
14266 South Fork Flathead River, and the habitat conditions, such as river elevation (stage), velocities,
14267 and temperatures in the river. These flow changes continue downstream to affect the main

14268 Flathead River in the same patterns, but somewhat attenuated by the flows in the mainstem
14269 Flathead. Temperatures in summer are regulated with a selective withdrawal structure that is
14270 operated to release water of a temperature that favors native fish. Under MO1 operations,
14271 outflows would be from nine to 21 percent higher than the No Action Alternative in July to
14272 September, similar in October, and then generally lower than the No Action Alternative through
14273 the fall, winter, and spring months. The winter flows would be one percent to 12 percent lower
14274 than the No Action Alternative and April to June flows would be four to 17 percent lower.

14275 The temperature control structure would still operate in the summer months as in the No
14276 Action Alternative so changes in outflows in this timeframe would not affect summer
14277 temperatures downstream.

14278 In the Flathead River down to Flathead Lake, habitat suitability under the No Action Alternative
14279 is a key issue due to unnaturally high flows in the summer and winter. Under MO1, July to
14280 September flows would be 2 to 10 percent higher than the No Action Alternative summer
14281 flows, and winter flows in MO1 would be slightly lower than the No Action Alternative. Spring
14282 peaks would also be slightly lower than the No Action Alternative. Winter flows lower than the
14283 No Action Alternative would improve winter habitat suitability slightly, and spring peaks only
14284 slightly lower than the No Action Alternative would continue to occasionally provide flushing of
14285 sediments from gravels to maintain habitat.

14286 The winter water temperature warming influence from the contribution of the South Fork
14287 Flathead would be slightly less due to slightly lower winter flows out of Hungry Horse. TDG in
14288 the Flathead River would be similar to the No Action Alternative, continuing to fluctuate with
14289 spill at Hungry Horse dam but generally-speaking, would not exceed 117 percent, which is
14290 within a safe zone for fish.

14291 The influence of MO1 changes to Flathead Lake levels and Seli's Ksanka Qlispe' Dam operations
14292 would be minimal compared to the No Action Alternative, and habitat conditions in these areas
14293 would be similar as described in the No Action Alternative.

14294 Bull Trout

14295 MO1 conditions would slightly reduce the summer production of zooplankton that provides
14296 forage for bull trout and surface area available for summer terrestrial insect feeding. The lower
14297 reservoir elevations and steeper drawdowns would result in substantially lower surface area for
14298 benthic insect production throughout the year, especially in the bays at the upper ends of the
14299 reservoir lobes. Juvenile bull trout moving into the reservoir in the spring rely on the benthic
14300 insects until they transition to eating fish. The prey items that adult bull trout eat also consume
14301 the benthic insects and may be in poorer condition or less plentiful in areas. This could result in
14302 bull trout being in poorer condition.

14303 Lower reservoir elevations in the fall would increase the risk and exposure to predation and
14304 angling pressure for upstream migrating bull trout. The sedimentation of tributary deltas
14305 currently is not known, but there could potentially be blockages of passage arise with lower

14306 elevations as well. These effects would likely be moderate in wet, average, and most dry years
14307 with 3 to 4 feet of difference from the No Action Alternative. In extremely dry years there could
14308 be much lower elevations (up to 12 feet lower than the No Action Alternative) and more
14309 extreme effects in years when the elevations would already be causing access and varial zone
14310 issues under the No Action Alternative.

14311 Bull trout entrainment through the dam would likely increase in MO1 due to increased outflows
14312 in late summer. Withdrawals in August and September are generally selected from deep in the
14313 water column to release the target temperature, and bull trout have been documented in this
14314 stratum at this time of year. Entrainment under the No Action Alternative is likely minimal and
14315 has not been quantified but would be expected to increase nine to 21 percent under MO1 as
14316 modeled.

14317 The number of individual bull trout in the South Fork Flathead River below Hungry Horse
14318 Reservoir may increase with greater entrainment, but these would be lost from their spawning
14319 populations because they only spawn above Hungry Horse dam but would be unable to ascend
14320 back up past the dam once they were flushed downstream of it. Zooplankton available in the
14321 South Fork Flathead River may increase in summer with higher outflows. As in the reservoir,
14322 food web relationships are important. MO1 would continue to allow for this transitory use by
14323 bull trout and other native fish with adequate food. Higher flows may also increase benthic
14324 production of food for bull trout prey fish, but increased velocities would result in lower
14325 availability of suitable habitat for bull trout.

14326 Summer flows in the mainstem would be higher than the No Action Alternative, further
14327 exacerbating issues with habitat suitability. Muhlfield et al. (2011) found even moderate
14328 increases in summer flows resulted in substantial decreases in suitable area for bull trout, and
14329 that nighttime habitat for subadult bull trout was most sensitive. The 2 to 10 percent increase
14330 due to MO1 would reduce bull trout habitat, especially for subadults. The mainstem Flathead
14331 River would be similar to the No Action Alternative in winter, with barely perceptible changes
14332 (slightly lower) from the No Action Alternative.

14333 Operations of Seli's Ksanka Qlispel Dam (Flathead Lake) would be similar to the No Action
14334 Alternative, and the bull trout habitat use and life history functions in Flathead Lake, the Lower
14335 Flathead River, and Clark Fork River would be similar to the No Action Alternative.

14336 Other Fish

14337 Hungry Horse Reservoir favors a native fish dominated fish community. Juvenile bull trout and
14338 adult whitefish, northern pikeminnow, sculpins, and westslope cutthroat trout feed on
14339 zooplankton, aquatic insects, and terrestrial insects, and adult bull trout prey on mountain
14340 whitefish, suckers, minnows, etc. The food web effects described above would also apply to all
14341 of these species of fish in Hungry Horse Reservoir. Slight decreases in zooplankton and reduced
14342 summertime feeding of terrestrial insects could reduce food supply slightly in summer.
14343 Substantial decreases in aquatic macroinvertebrate due to dewatering events and reduced
14344 surface area for production would decrease the food supply for many of these fish.

14345 Westslope cutthroat trout and other native fish spawn in the spring (April through June), so
14346 effects on adults migrating into tributaries to spawn would differ from bull trout. Spring
14347 spawning fish migrate when reservoir levels are lower and tend to experience longer varial
14348 zones with increased exposure to predation. Under MO1 operations, the modeled April and
14349 May elevations were five feet and three feet, respectively, lower than the No Action
14350 Alternative. By June, the elevation would be similar to the No Action Alternative. Given the
14351 modeling error, however, the April and May elevations would likely be 1 to 4 feet lower than
14352 the No Action Alternative. Spring spawning fish such as westslope cutthroat trout would
14353 experience greater varial zone effects on their way upstream as adults, and could encounter
14354 some tributary blockages, but the delta formation of these tributaries is not known. Juveniles
14355 typically outmigrate in June when the effects would be similar to the No Action Alternative.

14356 Entrainment from the reservoir would also continue at unquantified levels and could increase in
14357 the summer months with increased outflows. Northern pikeminnow and bull trout have been
14358 documented at the depths of late summer withdrawal and would be most susceptible to
14359 increased entrainment. Westslope cutthroat trout and other fish may experience some increase
14360 but would not be expected to be as susceptible to entrainment as bull trout because they are
14361 not commonly found at the depths of outlets. Entrainment would be expected to increase nine
14362 to 21 percent in the summer months and decrease slightly in winter.

14363 Habitat suitability described for bull trout would be similar for other native fish in the mainstem
14364 Flathead River (Muhlfield et al. 2011), with higher summer flows in MO1 resulting in decreased
14365 amount of suitable habitat for them in summer.

14366 Effects to fish in Flathead Lake, the lower Flathead River, and Clark Fork Rivers would be similar
14367 as described in the No Action Alternative.

14368 ***Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River***

14369 Summary of Key Effects

14370 Hydrology modeling showed that Lake Pend Oreille elevations, inflows, and outflows would be
14371 the same as the No Action Alternative. Biological relationships were dependent on these
14372 parameters, so the key effects of MO1 for bull trout, fish habitat, and other fish species in the
14373 Pend Oreille basin would be the same as those described under the No Action Alternative.

14374 **Region B**

14375 ***Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam***

14376 Summary of Key Effects

14377 The Columbia River from the U.S.-Canada border would continue to support a white sturgeon
14378 population that spawns successfully but primarily relies on fish manager intervention to survive
14379 a recruitment bottleneck; conditions for natural recruitment may be further diminished in a
14380 small proportion of years. Retention time is a key metric for most fish species in Lake Roosevelt,
14381 influencing food that supports the fish as well as influencing how many are entrained.

14382 Retention time would be lower in winter and early spring, especially in the wet years than the
14383 No Action Alternative, decreasing productivity and increasing entrainment. Lake elevations
14384 under MO1 would increase risk of impeded redband rainbow trout tributary habitat access and
14385 eggs drying out. The portion of kokanee that spawn in tributaries would continue to have
14386 access in fall similar to the No Action Alternative. Reservoir operations would continue to result
14387 in some level of burbot eggs drying out and the portion of kokanee that spawn on lake
14388 shorelines and would increase in MO1 compared to the No Action Alternative. MO1 would
14389 continue to support both wild and hatchery-raised kokanee, redband rainbow trout and
14390 hatchery rainbow trout as well as non-native warmwater game species such as walleye,
14391 smallmouth bass, and northern pike. Northern pike would likely continue to increase and
14392 invade downstream, and the lake elevations could decrease the ability for boat-based Northern
14393 pike suppression efforts. Rufus Woods Lake would continue to provide habitat for fish
14394 entrained from Lake Roosevelt and from limited production of shoreline spawning by some
14395 species; entrainment could increase in winter and decrease in summer months. TDG would be
14396 similar or less than No Action Alternative. The operational measures that could impact fish
14397 include the *Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Winter*
14398 *System FRM Space, Lake Roosevelt Additional Water Supply and Chief Joseph Dam Project*
14399 *Additional Water Supply.*

14400 Habitat Effects Common to All Fish

14401 Median peak outflows under MO1 would follow the same pattern as the No Action Alternative
14402 with peaks in early June and another, smaller peak in July. The MO1 flows in early spring
14403 through September are about 2 percent to 5 percent lower than the No Action Alternative.
14404 December flows are about 4 percent to 6 percent higher than the No Action Alternative. These
14405 peak outflows can influence the rate of entrainment from Lake Roosevelt into Rufus Woods
14406 Lake. TDG in the Grand Coulee tailwater is also a concern for fish in Rufus Woods Lake. Under
14407 the MO1 TDG would be lower than No Action Alternative.

14408 The duration that water stays in the reservoir (i.e., retention time) is a driving metric for the
14409 food web in Lake Roosevelt and influences the populations of several fish species.

14410 Under MO1, median retention time would be similar to the No Action Alternative in late spring,
14411 summer, and fall. In average years, retention time under MO1 would be 6 percent lower in
14412 December and January, and in dry years would be about 7 percent to 8 percent lower in
14413 December through February but slightly higher in May. In wet years is when retention time is
14414 lowest because more water is moving through the system, and MO1 would reduce retention
14415 times even further in these years by up to 10 percent in February and by 3 to 10 percent in the
14416 entire period of December through May.

14417 Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely
14418 directly on the food source provided by the zooplankton production and higher-level predators
14419 such as bull trout prey on these fish. With lower water retention times under MO1 in winter
14420 and spring, when retention times are already fairly low, there would be less food available to

14421 fish, and they would also tend to follow the food source and crowd down towards the dam,
14422 becoming more susceptible to entrainment.

14423 Bull Trout

14424 Under MO1, bull trout in Lake Roosevelt could continue to move to cooler locations in the
14425 reservoir and these refuges would remain similar to the No Action Alternative. High flow years
14426 would continue to influence bull trout distribution through flushing more of them from the
14427 river near the U.S.-Canada border down into Lake Roosevelt. Increased outflows in December
14428 could potentially increase entrainment of bull trout, but this would be negligible because of the
14429 scarcity of bull trout in Lake Roosevelt.

14430 Bull trout are also sensitive to contaminants that are found in this region and would continue to
14431 bioaccumulate contaminants as a top predator, but fluctuation events that mobilize mercury
14432 would be the same as the No Action Alternative.

14433 Other Fish

14434 White sturgeon recruitment would be dependent on flows exceeding 200 kcfs and appropriate
14435 temperatures in late June/early July. Under MO1, flow over 200 kcfs in June and July would
14436 have a slight decrease. These slightly reduced flows at the U.S.-Canada border would result in
14437 potentially minor decrease in white sturgeon recruitment window. MO1 reservoir levels would
14438 be similar, but slightly lower than the No Action Alternative in June and July. Other factors that
14439 would continue to influence sturgeon include predation by fish that are favored by reservoir
14440 conditions if larvae are flushed into the Lake Roosevelt. Slightly lower flows in spring could
14441 slightly reduce the risk of larvae entering Lake Roosevelt. The uptake of contaminants such as
14442 copper closer to the U.S.-Canada border being flushed downstream into the reservoir by high
14443 flows would also be slightly lower. Under MO1, recruitment of white sturgeon would continue
14444 to be a rare event supplemented by hatchery propagation, as larval sturgeon are captured and
14445 raised in hatcheries until they are past the window where recruitment has been shown to fail at
14446 a high rate. Once these juveniles are released back into the reservoir they continue to grow and
14447 survive well. The reservoir would continue to provide good conditions for growth and survival
14448 of these fish.

14449 Wild production of native fish such as burbot, kokanee and redband rainbow trout would
14450 continue to provide valuable resources in Lake Roosevelt. As described in the common habitat
14451 effects, these fish are the most sensitive to the effects of changing retention times. Under the
14452 No Action Alternative an estimated average of over 400,000 fish annually would be entrained,
14453 with 30 to 50 percent of them being kokanee, primarily of wild origin. Rainbow trout would be
14454 the second most entrained species. Under MO1 operations, increased entrainment would be
14455 expected in winter months as the outflows increase over the No Action Alternative and
14456 retention times are 7 percent to 10 percent lower. Previous entrainment studies (LeCaire 2000)
14457 indicated winter being a period relatively low entrainment; however, the prolonged drawdown
14458 period is expected to increase entrainment during this time. In wet years, entrainment would
14459 also be higher in March-May (3 percent to 8 percent lower retention time) which could increase
14460 entrainment to a moderate effect. Increased entrainment of zooplankton would decrease food

- 14461 availability that is key to winter survival and growth of several fish species including kokanee,
14462 juvenile burbot, and other juvenile fish.
- 14463 For tributary spawning species such as redband rainbow trout and a portion of the wild
14464 production of kokanee, tributary access at the right time of year is important. Reservoir
14465 drawdown in the spring creates barren tributary reaches through the varial zone, which directly
14466 and indirectly impedes migration to and from tributaries and the reservoir. Redband rainbow
14467 trout need access tributaries in the spring. Under MO1, reservoir elevations would be lower
14468 than the No Action Alternative levels in the critical spawning migration time of April to May in
14469 wet and dry years (equaling about 40 percent of years). This would be most critical in wet years
14470 (20 percent of years) when the median elevation would be 1,241 feet on April 1, which would
14471 be seven feet lower than the No Action Alternative. Migratory impacts, although not well
14472 documented, could be severe given the timing and extent of the drawdowns in MO1. Redband
14473 rainbow trout spawn in Sanpoil, Blue Creek, Alder, Hall Creek, Nez Perce Creek, Onion Creek,
14474 Big Sheep Creek, and Deep Creek. These tributaries higher in the basin are more susceptible to
14475 elevation changes because a smaller change in lake elevation would result in a larger area of
14476 exposure than tributaries closer to the dam. Additionally, increased exposure during migrations
14477 to these tributaries would increase the varial zone effect where migrating fish are more
14478 exposed to predation and angling due to lack of cover.
- 14479 Species such as kokanee and burbot that spawn on shorelines in Lake Roosevelt are susceptible
14480 to eggs drying out if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on
14481 shoreline gravels September 15 to October 15 and eggs incubate through February. Burbot
14482 tend to spawn successfully in depths provided by the No Action Alternative in the Columbia
14483 River and in Lake Roosevelt on shorelines near the Colville River in winter with eggs incubating
14484 through the end of March (Bonar et al. 2000). MO1, compared to the No Action Alternative,
14485 begins dropping 2 months sooner and would likely strand or dewater burbot and kokanee eggs.
14486 A higher proportion of eggs at all elevations would be affected.
- 14487 The portion of kokanee that spawn near the fall water surface elevation are more at greater
14488 risk. Fry sometimes also stay in the gravels and could become stranded as well. Burbot spawn
14489 later in the winter so would be less affected because the lake level would have already dropped
14490 seven feet lower than the No Action Alternative when eggs would be deposited. However, this
14491 same mechanism would also decrease habitat available compared to the No Action Alternative.
14492 The wet years would have steeper and deeper reservoir draft than the No Action Alternative
14493 and would result in increased stranding of burbot eggs. Lake elevations influence river stage
14494 clear up to the U.S.-Canada border, so burbot that spawn in the rivers would experience the
14495 same patterns of dewatering, but at lower magnitudes as the lake effect lessens with distance.
- 14496 Kokanee are very sensitive to water temperature, and during summer are found at depths
14497 below 120 m to find suitably cool water. Under the No Action Alternative, Lake Roosevelt is
14498 very weakly stratified but does have suitably cool water at this depth along with suitable levels
14499 of DO. Lake whitefish and mountain whitefish also likely use this cool water in the summer.

14500 Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish,
14501 crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all
14502 tolerate a wide range of environmental conditions and would continue to contribute to the
14503 fishery community under MO1, and continue to adversely impact native species via predation.
14504 The invasion downstream by northern pike is of concern, and the Lake Roosevelt Co-Managers
14505 are actively suppressing pike populations using gillnets set by boats as soon as they can get on
14506 the water in the spring until the boat ramp becomes unusable at an elevation of 1,235 feet.
14507 Under the No Action Alternative this occurs on April 15 in wet years. Boat ramp access would
14508 remain useable in dry and average years. Under MO1 in wet years, this would occur about six
14509 days 6 days sooner and preclude the ability for the pike suppression efforts for that period. For
14510 estimation purposes, one crew typically removes about 100 pike per week and they would
14511 operate three crews (Colville Tribe unpublished data), so opportunity loss of up to about six
14512 days under MO1 could result in an estimated 300 pike not removed. It should be noted that this
14513 is applicable to only one specific boat ramp, but the middle of Lake Roosevelt area becomes
14514 inaccessible earlier, at lake elevation 1,245'. Additionally, outflows and retention time would
14515 continue to influence the entrainment and downstream invasion of non-native gamefish below
14516 Chief Joseph Dam where ESA-listed anadromous salmonids would be susceptible to predation
14517 by them. During the time when pike juveniles would be most susceptible to entrainment (May
14518 to August), retention time under MO1 would be similar or slightly higher so entrainment risk for
14519 pike would be similar to the No Action Alternative or slightly lower. However, as adult pike
14520 distribution increases downstream in the reservoir, adults and juveniles both would become
14521 more susceptible to entrainment and the increased winter outflow would increase
14522 entrainment.

14523 Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt
14524 would experience similar effects as their native counterparts except for spawning and early
14525 rearing effects. In addition, the net pen locations are situated where the water quality can be
14526 affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG,
14527 and their eventual recruitment to the fishery can be affected by retention time coupled with
14528 reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May.
14529 Under the MO1, the water quality at these locations would be similar to the No Action
14530 Alternative, and the water retention time in May would be either similar or slightly higher so
14531 entrainment risk would be the same as the No Action Alternative or slightly less. The operators
14532 strive to release these fish to coincide with the initiation of reservoir refill when outflows are
14533 reduced, which under MO1 would be the same as the No Action Alternative, so these fish
14534 would continue to be release when water quality conditions would be suitable.

14535 The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake
14536 Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter
14537 drawdown periods. The earlier start to winter drawdown in MO1 may increase entrainment
14538 and boost populations in Rufus Woods Lake, where decreased outflows in August and
14539 September likely would decrease entrainment. This lake has more riverine characteristics with
14540 steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short
14541 water retention time and low productivity. High flows during late spring and early summer

14542 would continue to flush eggs and larvae from protected rearing areas similar to the No Action
14543 Alternative, but slightly lower magnitude. Median peak outflows occur in early June and would
14544 be about 2 2 percent lower than the No Action Alternative. TDG in the Grand Coulee tailwater is
14545 a concern for fish in Rufus Woods Lake; modeling showed TDG would be slightly lower than the
14546 No Action Alternative.

14547 ***Chief Joseph to McNary Dam***

14548 Summary of Key Effects

14549 Key effects to fish and aquatic resources from MO1 would be similar to the No Action
14550 Alternative for most species. Additional effects under MO1 include slightly reduced spring
14551 freshet flows that may lead to minor reductions in white sturgeon spawning success, and slight
14552 increases in temperatures during northern pikeminnow and smallmouth bass rearing periods.
14553 The operational measures that could impact fish in Region B include the *Update System FRM*
14554 *Calculation, Planned Draft Rate at Grand Coulee, Winter System FRM Space, Lake Roosevelt*
14555 *Additional Water Supply* and *Chief Joseph Dam Project Additional Water Supply*.

14556 Habitat Effects Common to All Fish

14557 Common habitat effects of MO1 are similar to those identified for the No Action Alternative
14558 with the exception that flows would be slightly reduced in the spring freshet and water
14559 temperatures slightly increased during the late summer and early fall. These changes would
14560 have minor effects to fish species in the Columbia River.

14561 Bull Trout

14562 Key effects to bull trout under MO1 would not differ from the No Action Alternative. Bull trout
14563 would continue to use mainstem habitats of the Columbia River from November through July
14564 for foraging, migration, and overwintering.

14565 Other Fish

14566 Effects to white sturgeon under MO1 are not expected to change from those under the No
14567 Action Alternative except that spring freshet flows would be reduced slightly, leading to minor
14568 reductions in white sturgeon spawning success. The number of days when flows at McNary
14569 Dam would be above 250 kcfs would be reduced by about half a day from 9.3 to 8.8 days during
14570 May through July.

14571 Key effects of MO1 relative the No Action Alternative for additional fish resources would
14572 include a slight increase of in late summer water temperatures during the rearing period for
14573 northern pikeminnow and smallmouth bass. This increase may lead to better growth and
14574 survival for these and other species with similar life history requirements. Other effects would
14575 be similar to the No Action Alternative.

14576 **Region C**

14577 ***Snake River Basin***

14578 Summary of Key Effects

14579 Key effects from MO1 that differ from those found under the No Action Alternative include
14580 warmer water temperatures during August and slight increases in TDG April through July from
14581 operational measures such as *Block Spill Test (Base + 120/115%)* and *Modified Dworshak*
14582 *Summer Draft*.

14583 Habitat Effects Common to All Fish

14584 Common habitat effects of MO1 are similar to those identified for the No Action Alternative
14585 with the exception of the changes discussed in the section above.

14586 Bull Trout

14587 Effects of MO1 to bull trout within the Snake River Basin that differ from the No Action
14588 Alternative include a reduction in cooling water releases from Dworshak reservoir in August
14589 that would result in an increase in water temperature in the Clearwater and Snake Rivers.
14590 However, this would have minor adverse effects to bull trout as they migrate out of mainstem
14591 habitats prior to these releases and should be in tributary habitats when this operation occurs.
14592 These same cold water releases would start earlier in the year than under the No Action
14593 Alternative and would reduce water levels in Dworshak Reservoir and potentially impact bull
14594 trout migration access to tributaries in late June and early July.

14595 Other Fish

14596 Effects to white sturgeon under MO1 are not expected to change from those recorded under
14597 the No Action Alternative except that slightly higher water temperatures would occur in August
14598 as a result of a decrease in the release of cooling water from Dworshak Reservoir. This increase
14599 in temperature may increase mortality to white sturgeon on low water years. Mass mortality
14600 events and increased single mortalities are observed more frequently during high temperature
14601 events, often coupled with sockeye mortality events.

14602 Key effects of MO1 relative the No Action Alternative for additional fish resources would
14603 include a slight increase of in late summer water temperatures during the rearing period for
14604 northern pikeminnow, smallmouth bass and other cool and warm water fish species, and
14605 changes in TDG during spill in the spring, summer, and fall. Water temperatures would increase
14606 in August by as much as 4 degrees Celsius. This increase would contribute to better growth and
14607 survival for these and other species with similar life history requirements.

14608 Increases in spill under MO1 would increase TDG slightly during the spring and summer spill
14609 season and reduce TDG considerably in the fall with the early cessation of spill. High TDG could

14610 have adverse effects to early life stages of resident fish that are not able to compensate for high
14611 TDG by changing depth. Other effects would be similar to the No Action Alternative.

14612 **Region D**

14613 ***Mainstem Columbia River from McNary Dam to the Estuary***

14614 Summary of Key Effects

14615 Bull trout would continue to use the Columbia River in limited numbers and seek thermal
14616 refugia available at the mouths of tributaries. White sturgeon could continue to successfully
14617 reproduce in years with adequate flow and temperature conditions; recruitment failure has
14618 continued to occur in the Columbia basin and the causes are not well understood. The *Block*
14619 *Spill Test (Base + 120/115%), Increased Forebay Range Flexibility, Additional Powerhouse*
14620 *Surface Passage, and Improved Fish Passage Turbines* are measures that could provide a
14621 beneficial effect to fish on the Mainstem Columbia River from the McNary Project to the
14622 estuary.

14623 Habitat Effects Common to All Fish

14624 Outflows from McNary Reservoir influence some of the fish relationships described in this
14625 section. Peak spring flows affect habitat maintenance for some species. Modeled monthly
14626 median outflows for MO1 are shown below. The percent change compared to the No Action
14627 Alternative is shown in parentheses.

- 14628 • April: 187187187187187,600 cfs (-2 percent)
- 14629 • May: 254254254254254,300 cfs (-2 percent)
- 14630 • June: 282282282282282,400 cfs (-1 percent)
- 14631 • July: 195195195195195,800 cfs (-1 percent)

14632 Other flow parameters referred to in this section refer to outflows of McNary Dam, which are
14633 indicative of flows on downstream through the other Projects.

14634 Bull Trout

14635 Bull trout are known to use the mainstem Columbia River to move between tributaries and
14636 have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et
14637 al. 2016). Water temperature is the most important habitat factor for bull trout in the
14638 mainstem Columbia. Under MO1, bull trout would continue to use the mainstem Columbia for
14639 migration between tributaries, as well as tributary mouths for passage and thermal refugia.

14640 Adult bull trout move downstream during fall and overwinter in reservoirs (October to
14641 February) (Barrows et al. 2016). Although bull trout successfully move between areas on the
14642 mainstem, their migration can be delayed at the dams. MO1 includes a structural measure for
14643 additional spillway passage at McNary Dam. The *Additional Powerhouse Surface Passage*

- 14644 measure would be in operation from March 1 through August 31, and could slightly improve
14645 bull trout downstream passage, but the majority of adult bull trout would have moved out of
14646 the mainstem by the time this surface passage route would be in use.
- 14647 Passage through turbines can cause injury or mortality, as well as migration delays. MO1
14648 includes the *Improved Fish Passage Turbines* measure, which would improve survival (Deng et
14649 al. 2019). At John Day, turbine replacement would provide safer passage for any bull trout that
14650 move through the dam.
- 14651 Bird predation on bull trout would continue to occur under MO1. New surface bypass designs
14652 under MO1 could shift bull trout into areas that are more susceptible to bird predation.
- 14653 Other Fish
- 14654 Under MO1, white sturgeon spawning and recruitment would be similar to the No Action
14655 Alternative, with a range of 48 days (2015) to 74 days (2012) with suitable conditions. The
14656 number of days with optimal embryo incubation (12°C to 14°C) would also be similar to the No
14657 Action Alternative, range from 6 days (2013) to 27 days (2011). In years of low flow conditions,
14658 water temperatures could increase beyond the suitable range by early June, resulting in little or
14659 no recruitment.
- 14660 Flows for successful sturgeon spawning and recruitment were analyzed based on the McNary
14661 tailrace. Since lower Columbia dams are run-of-river, the outflow at McNary Dam correlates
14662 with the outflows at John Day, The Dalles, and Bonneville Dams. Flows of at least 250 kcfs from
14663 April 1 to July 31, coupled with suitable temperatures, provide favorable spawning and rearing
14664 conditions. Compared to the No Action Alternative, there could be a slight reduction in the
14665 number of years with recruitment success under MO1. Model results indicate two fewer days
14666 of suitable conditions in median years and three fewer days in high flow years. Low flow years
14667 would likely not provide sufficient time with suitable flows for recruitment to occur, similar to
14668 the No Action Alternative.
- 14669 White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse
14670 substrates (Parsley et al. 1993). Minor changes in outflow under MO1 would not be large
14671 enough to cause discernable velocity changes that would affect sturgeon spawning habitat.
- 14672 Lack of effective upstream white sturgeon passage for all age classes decreases the connectivity
14673 of the population (Parsley et al. 2007). Under MO1, a measure to improve fish passage at
14674 Bonneville Dam would likely improve potential passage for sturgeon. The vertical slot fishway
14675 would make it easier for sturgeon to pass upstream.
- 14676 Turbine units at dams can cause injury and mortality in juvenile and adult sturgeon. Under
14677 MO1, improvements to turbines at John Day would reduce injuries and mortality of juvenile
14678 sturgeon (Deng et al. 2019).
- 14679 White sturgeon larvae are adversely affected by TDG. Studies have shown high rates of altered
14680 buoyancy at 118 percent TDG, and 50 percent mortality at 131 percent TDG (Counihan et al.

14681 1998). Adults are more able to compensate for increased TDG by moving to lower depths, but
14682 larvae in shallow water would be more affected. Under MO1, TDG rates would be similar to the
14683 No Action Alternative.

14684 Changes in a pool or tailrace elevation can affect juvenile white sturgeon through stranding in
14685 shallow water. Under MO1, pool elevations would be about 1 foot higher in the John Day pool
14686 from late March through early June (due to bird predation measures), and the drop in early
14687 June could strand larvae.

14688 Under MO1, lower flows at Bonneville during dry years in May and August could potentially
14689 increase pinniped predation rates, but it is also likely that sturgeon are avoiding the tailrace due
14690 to predation pressure.

14691 Resident fish such as sculpin, walleye, and smallmouth bass are predators of embryo and age-0
14692 white sturgeon. Under MO1, predation would continue to affect early life stages of white
14693 sturgeon.

14694 Reservoirs in the lower Columbia may be in maturation, in which sedimentation and invasive
14695 aquatic plants could reduce habitat value for sturgeon through changes in predation, food
14696 availability, and suitability for invasive species. This trend would not be expected to change
14697 under MO1.

14698 Under MO1, no changes to resident fish communities would be expected. As shown above,
14699 outflow rates below McNary Dam would be very similar to the No Action Alternative. Water
14700 quality and food availability would also be similar to the No Action Alternative.

14701 Conditions that promote lower water temperatures and higher spring flows tend to lower the
14702 survival rates of warmwater game fish, potentially lowering populations of predators on salmon
14703 and steelhead. MO1 would be expected to continue supporting warm water game fish at levels
14704 similar to current conditions.

14705 **MACROINVERTEBRATES**

14706 Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under MO1. For more
14707 detailed information on the effects of MO1 on aquatic invertebrates and implications on food
14708 web interactions see the Habitat Effects section of these respective fish community analyses in
14709 the Resident Fish section under the applicable region.

14710 **Region A**

14711 Project operations under MO1 would affect the aquatic environments provided by Hungry
14712 Horse Reservoir, South Fork Flathead River, Flathead River, Flathead Lake, lower Flathead River,
14713 Clark Fork River, Lake Pend Oreille, Pend Oreille River, Lake Kootenai, and the Kootenai River.
14714 These include the *Modified Draft at Libby*, *December Libby Target Elevation*, *Hungry Horse*
14715 *Additional Water Supply*, and *Sliding Scale at Libby and Hungry Horse* measures.

14716 At Hungry Horse reservoir, the varial zone that provides benthic insect production would be
14717 appreciably reduced due to steeper drafts in the summer and lower elevations through the
14718 winter months, and aquatic insects in this zone would become dewatered faster than under the
14719 No Action Alternative. The reservoir would miss filling in six more years out of 100 compared to
14720 the No Action Alternative, and the elevation at the end of September would be 4 to 5 feet
14721 lower than the No Action Alternative. With lower summer elevations the euphotic zone for
14722 summer zooplankton production would also decrease by 1 percent to 3 percent, and
14723 zooplankton being carried downstream out of the reservoir and into the South Fork Flathead
14724 River would increase with higher outflows of nine to 21 percent in the summer months.
14725 Zooplankton entrainment would generally be lower than the No Action Alternative in spring,
14726 fall, and winter. These outflows can increase zooplankton levels and wetted area for
14727 macroinvertebrate production in the South Fork Flathead River but could also flush more out of
14728 this area with higher velocities.

14729 MO1 operations would result in minimal changes to Flathead Lake, the lower Flathead River,
14730 and the Clark Fork River. These habitats would continue to support the macroinvertebrates
14731 described in the affected environment.

14732 The operations of Albeni Falls Project would be similar to the No Action Alternative operations
14733 and would not result in appreciable changes to Lake Pend Oreille or the Pend Oreille River, nor
14734 to the macroinvertebrate communities in those habitats.

14735 In the Kootenai basin, Lake Koocanusa would be held above elevation 2450 from three to
14736 thirteen more days than the No Action Alternative, which would increase the overall
14737 productivity of zooplankton and macroinvertebrates in the system. MO1 operations result in a
14738 median minimum pool elevation two feet lower than the No Action Alternative, exposing more
14739 varial zone and dewatering insect production, especially in dry years. The shallower draft
14740 through the winter compared to the No Action Alternative would lessen the effect to
14741 macroinvertebrate production.

14742 **Region B**

14743 The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic
14744 insects such as stonefly, caddisfly, and mayfly larvae. The operational measures that could
14745 impact macroinvertebrates under MO1 in Region B include the *Update System FRM Calculation*,
14746 *Planned Draft Rate at Grand Coulee*, *Winter System FRM Space*, *Lake Roosevelt Additional*
14747 *Water Supply* and *Chief Joseph Dam Project Additional Water Supply*.

14748 MO1 operations would change river elevations at the U.S.-Canada border in the months of
14749 December and January, with much steeper drops than the No Action Alternative. MO1 levels
14750 would follow the same pattern as the No Action Alternative through April with rising elevations
14751 until July, then dropping steeply until September, when they rise again. No Action Alternative
14752 and MO1 levels would then level off about November, but in December MO1, levels would drop
14753 quickly about 4 feet where No Action Alternative levels would rise slightly and hold steady for
14754 another month and then drop at a lower rate. MO1 would result in decreased habitat and more

14755 areas becoming dewatered compared to the No Action Alternative from December through
14756 about March 1. This change in elevation of 4 feet represents the vertical feet; actual habitat
14757 dewatered would depend on the slope of the riverbanks at this elevation. As the river flows
14758 downstream closer to Lake Roosevelt, the pattern is the same but the additional drop from
14759 MO1 would result in about six feet lower elevation at river mile 720.

14760 In Lake Roosevelt, the production, distribution and persistence of zooplankton is highly variable
14761 and sensitive to retention time of water in the reservoir, which is a function of inflows, reservoir
14762 volume, and outflows. Under MO1, the average water retention time in the reservoir would be
14763 similar to the No Action Alternative in late spring, summer, and fall. Water retention time under
14764 MO1 would be lower in December through January, but slightly higher in May in most years. In
14765 wet years is when retention time is lowest because more water is moving through the system,
14766 and MO1 would reduce retention times even further in these years by up to 10 percent in
14767 February and by 3 percent to 10 percent in the entire period of December through May. With
14768 lower retention times under MO1 in winter and spring, when retention times are already fairly
14769 low, there would be less productivity and increased entrainment of zooplankton. The elevations
14770 in Lake Roosevelt would follow the same pattern as in the river sections described above, with
14771 MO1 elevations dropping up to 6 feet lower by the end of December, rather than staying steady
14772 as in the No Action Alternative. This would result in desiccation of more aquatic
14773 macroinvertebrates and overall decreased habitat in shallow areas of the reservoir.

14774 Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with
14775 steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short
14776 water retention time and low productivity. Regarding aquatic insect production and
14777 desiccation, river stage at RM 594 in Rufus Woods Lake would follow the same pattern and
14778 magnitude changes as the No Action Alternative, so aquatic macroinvertebrate habitat would
14779 be the same. However, zooplankton production may decrease in response to changes in water
14780 retention time proposed under MO1.

14781 **Region C**

14782 The operational measures such as *Block Spill Test (Base + 120/115%)* and *Modified Dworshak*
14783 *Summer Draft* could impact macroinvertebrates in Region C. Low benthic production in
14784 Dworshak reservoir would be even further reduced under MO1 with a steeper drawdown
14785 starting about the third week of June. Extensive variation in water surface elevation, near-shore
14786 wave action that causes erosion and the lack of aquatic plants along the shoreline would
14787 continue to limit production. Likewise, the steeper drawdown in summer reservoir pool volume
14788 would further limit zooplankton production.

14789 In the Clearwater River below Dworshak Dam, flow augmentation released under MO1 would
14790 begin earlier in June than the No Action Alternative, but flows in August would be reduced
14791 compared to the No Action Alternative. The pattern of high flows followed by a steep drop and
14792 then followed by high flows again would limit benthic production in the Clearwater River
14793 compared to the No Action Alternative.

14794 The macroinvertebrate community of the lower Snake reservoirs and river would continue
14795 similar to the No Action Alternative. Warmer water temperatures could lead to a shift in
14796 zooplankton species, and these could experience more growth in the summer. Siberian prawns
14797 and opossum shrimp may continue to increase in the reservoir environments. The reservoirs
14798 would continue to provide habitat for clams, mussels, etc., as in the No Action Alternative, and
14799 crayfish would continue to find ample suitable habitat in the rock and riprap of reservoirs.

14800 **Region D**

14801 MO1 would result in only minor changes to flows or temperatures that could affect
14802 macroinvertebrate communities in the lower Columbia River from operational measures such
14803 as the *Block Spill Test (Base + 120/115%)* and *Increased Forebay Range Flexibility* measures.
14804 Very little benthic macroinvertebrate information is available for the lower Columbia River.
14805 Lake habitats in the impounded reaches would continue to support a low diversity of worms,
14806 benthic insects, and mollusks. In MO1, pool elevations would be about 1 foot higher in the John
14807 Day pool from late March through early June (due to bird predation measures), and then
14808 dropped in early June to the original level. During the period of March through early June,
14809 aquatic macroinvertebrates could colonize the additional benthic substrate and shallow water
14810 habitat afforded by the higher pool elevation but could be stranded or desiccated when levels
14811 drop in June. The other run of river dams would continue to be operated at stable elevations
14812 that would continue production of these aquatic macroinvertebrates.

14813 **SUMMARY OF EFFECTS**

14814 **Anadromous Fish**

14815 MO1 includes several structural measures intended to improve juvenile migration, including the
14816 *Additional Powerhouse Surface Passage*, *Upgrade to Adjustable Spillway Weirs* and *Improved*
14817 *Fish Passage Turbines* measures. Operationally, the *Block Spill Test (Base + 120/115%)* measure
14818 in the spring would generally increase the amount of spill at each of the lower Columbia and
14819 lower Snake projects for improved juvenile survival. The *Predator Disruption Operations*
14820 measure in the John Day reservoir would reduce juvenile predation by birds. Block spill during
14821 the spring was designed to test whether latent effects may be reduced slightly so that there
14822 could potentially be an increase in ocean survival and subsequent adult returns. Structural
14823 measures such as the *Additional Powerhouse Surface Passage* did not result in sizeable
14824 increases in juvenile survival or improvements in adult returns. Other structural measures in
14825 MO1 (e.g., *Lower Granite Trap Modifications*) would make small, incremental improvements in
14826 adult migration, but operational changes at Dworshak that were intended to improve thermal
14827 conditions for adult migrations in the Snake River actually would reduce adult migration
14828 success. Models predict that returns of salmon and steelhead would be similar to the No Action
14829 Alternative or higher. MO1 would have minor adverse effects for chum with mostly beneficial
14830 effects for lamprey, although there would be minor localized impacts. These effects are
14831 generally expected to be beneficial and negligible to minor as compared to the No Action
14832 Alternative.

14833 **Resident Fish**

14834 MO1 would continue many of the same key effects described in the No Action Alternative.
14835 Compared to the No Action Alternative, MO1 would have minor to moderate adverse effects in
14836 Region A due to changes in reservoir elevations and outflows reducing productivity, higher
14837 entrainment, increased varial zone effects where fish are subject to higher predation and
14838 access issues at tributary mouths, and diminished habitat in rivers downstream of reservoirs.
14839 These would affect bull trout, Kootenai River White sturgeon, and other native fish such as
14840 westslope cutthroat trout, and there would be some minor localized beneficial effects. In
14841 Region B, there would be minor to moderate adverse effects in Lake Roosevelt fish due to
14842 changes in retention time driving productivity and entrainment, habitat connectivity, stranding
14843 of kokanee and burbot eggs, habitat access for several species, and varial zone effects to
14844 redband rainbow trout. There would be negligible to minor adverse effects to white sturgeon
14845 from flow changes. In Region C, minor increases in late summer water temperatures and TDG in
14846 certain reaches such as the Snake River Basin would improve conditions for northern
14847 pikeminnow and invasive species such as smallmouth bass, adversely affecting conditions for
14848 native resident fish. Resident fish in Region D would see minor changes in flows and
14849 temperatures resulting in negligible effects to bull trout, white sturgeon, and other resident
14850 fish. While MO1 results in both beneficial and adverse effects on resident fish, overall, these
14851 effects are expected to be negligible, minor, or in some cases localized moderate as compared
14852 to the No Action Alternative.

14853 **Macroinvertebrates**

14854 The production, distribution, and persistence of macroinvertebrates are highly variable and
14855 sensitive to retention time of water in the reservoir, which is a function of inflows, reservoir
14856 volume, and outflows. In certain areas, such as at Hungry Horse and Dworshak Reservoirs, the
14857 varial zone that provides benthic insect production would be appreciably reduced due to
14858 steeper drafts in the summer and lower elevations through the winter months would result in
14859 aquatic insects becoming dewatered faster than under the No Action Alternative. In other
14860 areas, such as Lake Koocanusa, increases in timing of elevation as compared to the No Action
14861 Alternative would increase the overall productivity of zooplankton and macroinvertebrates in
14862 the system. Overall, MO1 contains both beneficial and adverse effects, which on balance are
14863 expected to be negligible to moderately adverse as compared to the No Action Alternative.

14864 **3.5.3.5 Multiple Objective Alternative 2**

14865 **ANADROMOUS FISH**

14866 **Salmon and Steelhead**

14867 Several different ESU/DPS units of salmon and steelhead share a similar life cycle and
14868 experience similar effects from the MOs, but also have ESU/DPS specific traits that specifically
14869 drive effects differently from one another. Common effects analyses across all salmon and
14870 steelhead are discussed first, and then those ESU/DPS specific effects are displayed. Unless

14871 otherwise noted, quantitative results from COMPASS, CSS, and the Life Cycle Model (LCM) are
14872 based on a combination of hatchery and natural origin fish. This applies for both juvenile and
14873 adult results.

14874 ***Effects Common Across Salmon and Steelhead***

14875 Summary of Key Effects

14876 MO2 includes structural measures to improve survival of juvenile salmon and steelhead, but
14877 lower flow and spill would, generally speaking, increase travel time and the number of
14878 powerhouse encounters for juvenile outmigrants. Anadromous juveniles outmigrating in the
14879 Snake River would be transported at a higher rate than the No Action Alternative, which could
14880 result in more reaching Bonneville Dam sooner than in-river fish. Depending on ocean survival
14881 dynamics, more or fewer adults could return, and returning adults would likely have higher
14882 rates of straying and migration delays due to higher rates of transported juveniles.

14883 Juvenile Fish Migration/Survival

14884 There are several structural measures in MO2 that could affect juvenile salmon and steelhead.
14885 Three of these were also in MO1 and were described in detail in the Common Effects to Salmon
14886 and Steelhead under MO1 section. Juvenile modeling included adjustments in the models to
14887 account for the effects of these measures, and they are considered qualitatively where
14888 modeling is not available. These include:

- 14889 • *Additional Powerhouse Surface Passage* measure at Ice Harbor, McNary, and John Day
14890 Projects: This would route additional juvenile fish away from turbine passage routes to
14891 spillway or spillway-like routes, likely decreasing travel times and increasing survival. See
14892 MO1 Common Effects for details. A key difference in MO2 however is a powerhouse surface
14893 collection facility designed to allow for smolt transportation at McNary Dam this significant
14894 design modification is different from MO1. Even with the most optimistic 30 percent
14895 passage efficiency assumption in place, the effect of these powerhouse surface passage
14896 structures on in-river survival and subsequent adult returns was minor. These structures
14897 could potentially be more effective at influencing population level dynamics at lower spill
14898 levels than those included in MO1, but even with reduced spill levels associated with MO2,
14899 there were not enough fish passing via the powerhouse to have a meaningful impact.
- 14900 • *The Improved Fish Passage Turbines* measure at the John Day Project would improve
14901 juvenile survival of the juveniles that pass through this turbine route. See MO1 Common
14902 Effects for details.

14903 MO2 also includes measures that would affect juvenile salmon and steelhead that were not in
14904 MO1, with the objective of improving power generation or complementing power with
14905 increased fish transport. They are:

- 14906 • *Fewer Fish Screens* measure at Ice Harbor, McNary and John Day Projects:

14907 Fish screens are installed to divert juvenile salmon and steelhead from turbine routes to
14908 higher survival spill routes. However, most turbines were designed to operate without
14909 screens and the addition of these screens generally reduces turbine efficiency and
14910 flexibility. Removing these screens would restore operating ranges and efficiencies while
14911 decreasing O&M costs.

14912 Effects on fish from this structural change would be generally adverse to most fish species.
14913 We would expect an increase in the numbers of fish experiencing turbine routes at these
14914 dams, while juvenile salmon and steelhead, and most other species of fish, would
14915 experience increased mortality. By contrast, lamprey, which experience impingement on
14916 some of the screens, would likely see increases in survival as they pass the dams.

14917 • *Increase Juvenile Fish Transportation* measure: Increasing juvenile fish transportation would
14918 affect Snake River and Columbia River fish. First, all Snake River smolts would be collected for
14919 transportation at the three Snake River collector projects, with none being bypassed back to
14920 the river. Juvenile fish would also be collected and transported from the powerhouse surface
14921 passage structure at McNary Dam. Changes in Snake River transport are incorporated into
14922 models, but because COMPASS and CSS models are not calibrated to data utilizing McNary
14923 transport facilities, model results do not reflect the effects of this measure. A rough estimate
14924 conducted by NMFS indicates that approximately an additional 9 percent of Chinook and 7
14925 percent of steelhead would likely be transported using a powerhouse surface passage for
14926 collection. Additionally, the lower spill in MO2 would increase the number of juveniles entering
14927 juvenile bypasses and therefore available to be collected for transportation. Increasing the
14928 total fraction of natural and hatchery origin smolts transported from Lower Granite, Little
14929 Goose, and Lower Monumental dams will increase the average return rates to Bonneville Dam
14930 of the outgoing cohort of Snake River spring-run/summer-run Chinook. However, lower adult
14931 conversion rates upstream are also associated with fish that were transported as juveniles
14932 (Marsh et al. 2015; FPC memo 13-19). The increased conversion risk for adults would offset
14933 some of the benefits from the higher adult returns resulting from a higher season-wide
14934 transport rate of juveniles. As a result, transportation of natural and hatchery origin Snake
14935 River spring-run/summer-run Chinook smolts from McNary Dam may have a neutral effect on
14936 SARs (Marsh et al. 2010). Changes in transport are discussed more specifically by ESU/DPS, if
14937 applicable.

14938 Several operational measures warrant discussion here individually, regarding effects to juvenile
14939 fish. Measures that would result in changes to spill, flows, passage routes, or temperatures
14940 were incorporated into the fish models. Others are not readily incorporated into modeling for
14941 effects analysis, or are modeled but may be difficult to separate from other factors, and so
14942 effects of these measures are discussed qualitatively.

14943 • *Full Range Reservoir Operations* and *John Day Full Pool* measures: Increasing the operating
14944 range at the four lower Snake River dams and John Day Dam to their full operating ranges
14945 would slightly increase juvenile fish travel times and exposure to predators, but the pools
14946 would not be at full pool elevations throughout the migration season. To better understand

- 14947 how these elevations change throughout the season, see the Hydrology and Hydraulics
14948 modeling section of this EIS.
- 14949 • *Contingency Reserves in Fish Spill* measure: Holding contingency reserves within juvenile
14950 fish passage spill is likely to have little effect on juvenile migration. Contingency reserves
14951 would be expected to be deployed at a level that would impact fish spill levels
14952 approximately once a month and are, by definition, limited to no more than 1 hour in
14953 duration. See Section 3.7, Power Generation and Transmission for more information.
- 14954 • *Full Range Turbine Operations* measure: Operating turbines within and above 1 percent
14955 efficiency may or may not affect juvenile salmon and steelhead direct survival based on
14956 studies finding that peak passage survival does not coincide with observed turbine peak
14957 operating efficiency (Mathur et al. 2000; Skalski et al. 2002; Deng et al. 2007). A meta-
14958 analysis also found no association between relative turbine efficiency at a site and smolt
14959 passage survival (Skalski et al. 2002). However, Ferguson et al. (2006) reported spring-run
14960 Chinook delayed mortality resulting from operation of McNary Dam turbines outside the 1
14961 percent range, so it is possible that operating outside 1 percent turbine efficiencies at some
14962 dams may decrease juvenile survival.
- 14963 • *Zero Generation Operations* measure: Extending the zero generation operation measure
14964 would not affect juvenile salmon or steelhead because they are not migrating in the late
14965 fall/winter timeframe when this measure occurs. However, impacts to adult passage
14966 (especially for Snake River steelhead) would be anticipated due to this operation.
- 14967 • The measures intended to improve conditions for lamprey in this alternative are anticipated
14968 to have a negligible effect on salmon and steelhead survival.
- 14969 MO2's *Spill to Near 110% TDG* decreases the proportion of spill at each of the lower Columbia
14970 and lower Snake projects compared to the No Action Alternative. This reduced spill has the net
14971 effect of routing more juvenile salmon and steelhead towards powerhouse routes and less
14972 salmon and steelhead through spill routes. For juvenile salmon and steelhead, fish modeling
14973 was used when available to estimate the effects of these spill changes on fish.
- 14974 Flow patterns in the Lower Columbia River would also change in MO2 relative to the No Action
14975 Alternative and these included median decreases in monthly average flows of 4 percent in
14976 March, and increased winter flows of 5 to 9 percent in November and December. Other months
14977 would be within 1 to 3 percent of No Action Alternative flows. In the Lower Snake River, flows
14978 would be about 18 percent higher in January and 5 percent higher in February, with lower flows
14979 in June (-3 percent) and July (-5 percent). Similar to the spill changes, fish modeling was used
14980 when available to estimate the effects of these flow changes on juvenile fish. These flow
14981 changes were caused by one or a combination of the following operational measures:
- 14982 • *Slightly Deeper Draft for Hydropower*
- 14983 • *Sliding Scale at Libby and Hungry Horse*
- 14984 • *Modified Draft at Libby*

- 14985 • *December Libby Target Elevation*
- 14986 • *Update System FRM Calculation*
- 14987 • *Planned Draft Rate at Grand Coulee*
- 14988 • *Grand Coulee Maintenance Operations*
- 14989 • *Winter System FRM Space*

14990 MO2 is similar to the No Action Alternative from a TDG perspective but shows a small reduction
14991 in average TDG exposure. UW/CBR TDG modeling, separate from COMPASS and CSS in-river
14992 survival estimates, estimated juvenile fish median reach average exposure to TDG indices would
14993 decrease by about 2 percent relative to the No Action Alternative.

14994 There may be increases in fish injury under MO2 with the higher number of turbine passages
14995 relative to the No Action Alternative, but reduced to some degree by installation of improved
14996 fish passage turbines at John Day Dam. However, water velocities and turbidity are not
14997 anticipated to change under MO2 relative to the No Action Alternative. There may be an overall
14998 increase in juvenile fish predation exposure under MO2 due to these factors relative to the No
14999 Action Alternative, but the magnitude is uncertain.

15000 Adult Fish Migration/Survival

15001 MO2 includes one measure, *Lower Snake Ladder Pumps*, which would install pumping systems
15002 to provide deeper, cooler water if available in the forebays to adult fish ladders at Lower
15003 Monumental and Ice Harbor Dams, intended to reduce delays in upstream adult passage. This
15004 measure is also in MO1 and is described and analyzed in more detail in the Common Effects
15005 section of MO1.

15006 Reduction in spill throughout the lower Columbia and lower Snake projects is anticipated to
15007 reduce adult fallback rates in spring migrants that cause migratory delays (Boggs et al. 2004;
15008 Keefer et al. 2005) under MO2 and its *Spill to Near 110%* measure.

15009 Increasing the operating range at the lower Snake River projects and at John Day Project
15010 through the *Full Range Reservoir Operations* and *John Day Full Pool* measures would have little
15011 effect on flow, and thus is not expected to affect adult migration timing or survival rates.
15012 Similarly, holding contingency reserves within juvenile fish passage spill is likely to have little
15013 effect, if any, on adult migration.

15014 The following measures are summarized in the juvenile effects section and in detail in the
15015 Summary of Common Effects under MO1. These measures are also in MO2, and in addition to
15016 juvenile effects would result in the following effects to adult migration and survival:

- 15017 • *Additional Powerhouse Surface Passage* at Ice Harbor, McNary, and John Day Dams could
15018 reduce travel time and improve downstream migration of steelhead kelts.

15019 • Installing Improved Fish Passage (IFP) Turbines at John Day Dam could increase survival of
15020 salmon and steelhead that overshoot John Day Dam as well as steelhead kelts that pass
15021 back downstream through turbines.

15022 As described under juvenile fish, flows would be about 4 percent lower in March and 3 to 7
15023 percent higher in November and December in the lower Columbia River. Snake River flows
15024 would be about 18 percent higher in January and 5 percent higher in February. Any
15025 anadromous salmonids in the Columbia River or Lower Snake River at these times may be
15026 affected by these changes, as described below.

15027 In general, there are no major water temperature changes expected as a result of MO2 but for
15028 some species in some locations, there may be localized effects. Where applicable those effects
15029 are discussed in the species-specific write-ups. Summer water temperatures in the Snake River
15030 during the most upstream migrations would not change from the No Action Alternative, nor
15031 would the percentage of days in which the ladder temperature would be more than 2 degrees
15032 Celsius warmer than the river temperature. However, Dworshak Reservoir operations would be
15033 affected such that the probability of refilling the reservoir would be lower, resulting in higher
15034 risk of not having enough water in the reservoir to provide summer cooling water.

15035 ***Upper Columbia River Salmon and Steelhead***

15036 Upstream of McNary Dam, upper Columbia salmon and steelhead migrate past as many as five
15037 PUD owned dams and reservoirs that also impact the survival and passage of these species. The
15038 federal agencies do not dictate generation or spill levels at the PUD projects so metrics such as
15039 powerhouse encounter rate are not directly affected but are influenced by river flow levels
15040 coming through the upper Basin. The timing and volume of flow levels affected by CRS
15041 operational decisions are reflected in model analysis. COMPASS and LCM estimates of
15042 powerhouse encounter rate and SARs include passage effects from a combination of federal
15043 and PUD dam passage (Rock Island Dam to Bonneville Dam).

15044 Upper Columbia Spring-Run Chinook Salmon

15045 *Summary of Key Effects*

15046 The structural and operational measures in MO2 overall would reduce juvenile survival from
15047 McNary Dam pool to Bonneville Dam with longer travel times and increased powerhouse
15048 encounters. Adult migration success may be enhanced by lower spill, but with lower juvenile
15049 survival, overall abundance of returning adults to spawning grounds would be about 3 percent
15050 lower than the No Action Alternative. Some upper Columbia Chinook salmon would be
15051 transported from McNary Dam under this operation, but the effects could not be quantitatively
15052 assessed.

15053 *Juvenile Fish Migration/Survival*

15054 This ESU migrates through the Columbia River downstream past the four lower CRS projects as
15055 well as up to five non-federal dams. Structural and operational measures described in the
15056 Common Effects section that describe changes from the No Action Alternative at McNary, John
15057 Day, The Dalles, and Bonneville Projects would apply to these fish. Additional surface passage
15058 and upgrading spillway weirs at McNary and John Day Dams may improve juvenile survival but
15059 removing fish screens at both dams would result in more juvenile fish going through turbines,,
15060 though improved turbines could offset this effect with increased survival of turbine route fish.
15061 COMPASS modeling indicates MO2 would decrease juvenile survival about 1.3 percent, increase
15062 travel time 7 percent and increase the number of powerhouse routes encountered by juvenile
15063 fish by 11 percent. TDG exposure would generally be lower than the No Action Alternative for
15064 these fish (Table 3-79). Overall, juveniles would likely encounter increased predation risk in
15065 MO2, compared to the No Action Alternative, with longer travel times and increased
15066 powerhouse encounters between McNary and Bonneville dams.

15067 **Table 3-79. Multiple Objective Alternative 2 Juvenile Model Metrics for Upper Columbia River**
15068 **Spring-Run Chinook Salmon**

Metric (Model)	NAA	MO2	Absolute Change from NAA	Percent Change from NAA
Juvenile Survival (COMPASS) McNary to Bonneville	69.5%	68.2%	-1.3%	-2%
Juvenile Travel time (COMPASS) McNary to Bonneville	6.1 days	6.5 days	+0.4 days	+7%
% Transported	Not Quantitatively Estimated			
Powerhouse Passages (COMPASS) Rock Island to Bonneville	3.29	3.66	+0.37	+11%
TDG Average Exposure (TDG Tool) McNary to Bonneville	115.9% TDG	113.0% TDG	-2.9% TDG	-3%

15069 *Adult Fish Migration/Survival*

15070 There are no structural measures in MO2 to benefit upstream migration of adult upper
15071 Columbia River spring-run Chinook salmon. Adult exposure to TDG would be lower than the No
15072 Action Alternative, and lower spill levels would generally reduce migration delays and fallback.

15073 With decreased juvenile survival and slower juvenile travel time, the SARs and the resulting
15074 abundance of returning adults would be expected to decrease under MO2 compared to the No
15075 Action Alternative. NWFSC LCM modeling predicted MO2 would result in a 3 percent decrease
15076 in median abundance, based on modeling of the Wenatchee population. This prediction
15077 assumes no change in potential latent mortality of juvenile fish compared to the No Action
15078 Alternative. Estimates of potential increases or decreases in ocean mortality were not
15079 computed for MO2. Table 3-80 displays the model results for the Wenatchee population:

15080 **Table 3-80. Multiple Objective Alternative 2 adult model metrics for Upper Columbia River**
15081 **Spring-Run Chinook salmon**

Metric (Model)	NAA	MO2	Change from NAA	%Change
Rock Island to Bonneville McNary to Bonneville SARs ^{1/} (NWFSC LCM)	0.94%	0.93%	-0.01%	-1%
Abundance ^{2/} of the Wenatchee population, representative of the ESU (NWFSC LCM)	498	482	-16	-3%

15082 1/ SAR estimates include passage effects from three non-federal dams.

15083 2/ Abundance estimates do not assume any latent effects from Columbia River System passage.

15084 Upper Columbia River Steelhead

15085 *Summary of Key Effects*

15086 COMPASS modeling estimates that MO2 is expected to result in a 4 percent decrease in average
15087 juvenile survival for upper Columbia steelhead between McNary and Bonneville dams; no
15088 change in average juvenile travel time is expected, but a six percent increase in the number of
15089 powerhouse passage events compared to the No Action Alternative would occur.

15090 *Juvenile Fish Migration/Survival*

15091 Juveniles from this DPS migrate downstream past the four lower CRS projects and through up
15092 to five PUD owned dams in the mid-Columbia. Operations at upstream reservoirs that affect
15093 seasonal flow patterns downstream influence travel time and survival at the PUD owned
15094 projects. Structural and operational measures described in the Common Effects section,
15095 including the *Additional Powerhouse Surface Passage* measure at McNary and John Day, and
15096 the *Upgrade to Adjustable Spillway Weirs* measure at McNary would improve spill passage
15097 effectiveness, but removing fish screens at McNary Dam and John Day Dam would increase
15098 turbine routes and increase mortality of juveniles. Juveniles collected at the powerhouse
15099 surface bypass at McNary would be transported within season. COMPASS modeling predicts
15100 juvenile survival under MO2 would decrease 2.4 percent, travel time would be the same as the
15101 No Action Alternative, and powerhouse encounters would increase. TDG exposure would be
15102 less than the No Action Alternative. MO2 Table 3-81 displays the juvenile metrics for upper
15103 Columbia River steelhead. Overall, juveniles could encounter increased predation risk in MO2,
15104 compared to the No Action Alternative, with increased powerhouse encounters between
15105 McNary and Bonneville dams.

15106 **Table 3-81. Multiple Objective Alternative 2 Juvenile Model Metrics for Upper Columbia River**
15107 **Steelhead**

Metric (Model)	NAA	MO2	Change from NAA	% Change
Juvenile Survival (COMPASS) McNary to Bonneville	65.8%	63.4%	-2.4%	-4%
Juvenile Travel Time (COMPASS) McNary to Bonneville	6.6 days	6.6 days	0 days	0%
% Transported (COMPASS)	Not Quantitatively Estimated			

Metric (Model)	NAA	MO2	Change from NAA	% Change
Powerhouse Passages (COMPASS) Rock Island to Bonneville	2.72	2.89	+0.17	+6%
TDG Average Exposure (TDG Tool)	116% TDG	113.1% TDG	-2.9% TDG	-3%

15108 MO2 includes a measure to increase transportation, including transport from McNary Dam.

15109 *Adult Fish Migration/Survival*

15110 As described in the Common Effects, upstream migration of adult steelhead would be improved
15111 by lower spill and lower TDG. The structural measures designed to improve juvenile fish
15112 survival, including additional surface passage, spillway weir upgrades, and improved fish
15113 passage turbines, would increase survival of steelhead kelts. Life cycle models were not
15114 available for steelhead, but overall abundance would likely be lower than the No Action
15115 Alternative due to decreased survival of juveniles.

15116 Upper Columbia River Coho Salmon

15117 See upper Columbia spring-run Chinook salmon analysis as a surrogate for juvenile upper
15118 Columbia coho salmon and upper Columbia fall Chinook salmon analysis as a surrogate for
15119 adult upper Columbia coho salmon.

15120 *Summary of Key Effects*

15121 The primary challenges for upper Columbia River coho salmon are the conditions they
15122 encounter during upstream and downstream migrations. Juvenile Upper Columbia coho salmon
15123 would survive similar to juvenile Upper Columbia spring-run Chinook salmon; minor decreases
15124 are expected due to operation and structural changes that would result in slower travel time
15125 and more powerhouse encounters. Upper Columbia Fall Chinook are the more appropriate
15126 surrogate for adult Upper Columbia coho salmon and based on surrogate analysis, minor
15127 decreases in adult returns would be expected.

15128 *Juvenile Fish Migration/Survival*

15129 Juvenile survival of upper Columbia River coho salmon is estimated using COMPASS juvenile
15130 modeling results for upper Columbia River spring-run Chinook salmon as a surrogate. Structural
15131 and operational measures contributing to changes in MO2 include increased surface passage
15132 structures, upgrading to adjustable spillway weirs, installation of improved fish passage
15133 turbines, and removal of fish screens at McNary Dam. These are discussed in the Common
15134 Effects section.

15135 Overall, juveniles would likely encounter increased predation risk in MO2, compared to the No
15136 Action Alternative, with longer travel times and increased powerhouse encounters between
15137 McNary and Bonneville dams.

15138 *Adult Fish Migration/Survival*

15139 Measures described in the Common Effects section that affect the four lower Columbia River
15140 projects would apply to upstream migration and survival of adult upper Columbia River coho
15141 salmon. Adult migration conditions would be similar to upper Columbia River fall-run Chinook
15142 salmon, which were analyzed in workshops using water quality and hydrology information.
15143 MO2 water quality modeling indicated no change in the frequency of water temperatures
15144 exceeding 20°C, nor any change in ladder temperature differentials in the lower Columbia
15145 relative to the No Action Alternative. The late run of upper Columbia River coho salmon
15146 migrates upstream in November and December, when flows would increase an average of 9
15147 percent in the Columbia River below McNary Dam.

15148 See upper Columbia Fall Chinook salmon analysis as a surrogate for adult upper Columbia coho
15149 salmon.

15150 Upper Columbia River Sockeye Salmon

15151 Refer to the upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia
15152 River sockeye salmon.

15153 *Summary of Key Effects*

15154 Juvenile sockeye salmon would experience lower survival during outmigration in the river than
15155 under the No Action Alternative. The most important change for Columbia River sockeye from
15156 MO2 is the potential for transportation of juveniles, which can improve survival but may have
15157 the consequence of higher rates of straying when they return as adults.

15158 *Juvenile Migration/Survival*

15159 Reduced spill operations in MO2 is expected to result in minor increases to juvenile upper
15160 Columbia River sockeye migration times compare to the No Action Alternative. River flows
15161 during the driest 25 percent of years would be slightly lower, but there would not be a
15162 substantial difference from the No Action Alternative. Juveniles would encounter more
15163 powerhouses, but this may partly be offset by increased survival through expected turbine
15164 improvements. TDG exposure would be lower than the No Action Alternative. Overall juveniles
15165 would likely encounter increased predation risk and reduced survival, as indicated by a minor
15166 decrease in survival indicated by the COMPASS modeling of the surrogate species, upper
15167 Columbia River spring-run Chinook salmon.

15168 In MO2, there is potential for transport of juvenile fish starting at McNary Dam, which would
15169 likely lead to an increase in the adverse effects of fallback and straying by the adult fish that
15170 were transported as juveniles.

15171 Overall, juveniles would likely encounter increased predation risk in MO2, compared to the No
15172 Action Alternative, with longer travel times and increased powerhouse encounters between
15173 McNary and Bonneville dams.

15174 *Adult Migration/Survival*

15175 MO2 would have a minor increase in the percentage of days over 18°C as measured at McNary
15176 and Chief Joseph Dams. For sockeye salmon, the inflection point for the survival/temperature
15177 relationship is 18°C. This relationship is not as strong for upper Columbia sockeye because they
15178 typically migrate 5 to 7 days earlier than Snake River sockeye. The water temperature at Chief
15179 Joseph Dam influences sockeye that use the nearby tributary of Okanogan River. Okanogan
15180 sockeye arrive at the confluence of the Okanogan River with the Columbia River when water
15181 temperatures are warmer than 21°C, and then hold in the mainstem Columbia River. From
15182 around July 1 until the end of August, sockeye hold in the mainstem of the Columbia River until
15183 they get a temperature break in the Okanogan River and are then able to move upstream
15184 toward their spawning areas. Earlier runs of fish are more successful. The cumulative stress of
15185 moving up through warm water in the Columbia River and then experiencing warm water at the
15186 confluence of the Okanogan River where they hold could increase the cumulative stress, which
15187 may decrease adult fish survival. The minor increase in days over the 18°C under MO2 would
15188 have a corresponding increase in stress from elevated water temperatures.

15189 Upper Columbia River Summer/Fall-Run Chinook Salmon

15190 *Summary of Key Effects*

15191 See Upper Columbia River spring-run Chinook analysis as a surrogate for upper Columbia River
15192 Summer/Fall Run Chinook Salmon.

15193 No change is anticipated in McNary and John Day reservoir plankton communities or shoreline
15194 habitats under MO2, relative to the No Action Alternative. Likewise, juvenile rearing habitat
15195 below Bonneville Dam is not expected to change relative to the No Action Alternative. Overall,
15196 no changes are anticipated for juvenile upper Columbia summer/fall-run Chinook.

15197 *Juvenile Fish Migration/Survival*

15198 Upper Columbia River Summer/Fall Run Chinook Salmon would likely experience lower juvenile
15199 survival, with small increases in travel time and powerhouse encounters. Lower TDG would
15200 benefit both juvenile and adult fish, and adult migration would be increased with lower fallback
15201 and delays due to spill. Overall abundance under MO2 would likely be less than No Action
15202 Alternative due to juvenile effects.

15203 *Adult Fish Migration/Survival*

15204 The number of days water temperatures in the McNary tailrace exceed 20°C and the number of
15205 days that adult ladder temperature differentials exceed 2°C would not change relative to the
15206 No Action Alternative. No changes in migration delay, fallback, or susceptibility to disease are
15207 anticipated due to overall warmer mainstem water temperatures at the lower Columbia dams
15208 (Caudill et al. 2013).

15209 Specific to Okanogan upper Columbia summer/fall-run Chinook, there is no change in number
15210 of days the mainstem would be 20°C or higher at the confluence of the Okanogan, relative to
15211 the No Action Alternative as opposed to the 18°C threshold discussed above for sockeye
15212 salmon. This means that there would be no change anticipated in the ability of the Okanogan
15213 fish to hold in the mainstem until temperatures in the Okanogan are cool enough that adults
15214 can move up from the mainstem without having to migrate through water temperatures
15215 typically considered lethal for salmon and steelhead (Ashbrook et al. 2009).

15216 The frequency of meeting the Vernita Bar Agreement to protect the prolific fall-run Chinook
15217 spawning in and around the Hanford Reach of the Columbia River in Washington is not
15218 expected to change under any MOs relative to the No Action Alternative. Other operational
15219 changes under MOs are likewise not anticipated to affect upper Columbia River summer/fall-
15220 run Chinook spawning from the tailrace of Chief Joseph Dam to Bonneville Dam in terms of
15221 changes in flows, water temperatures, or TDG generated under the MOs.

15222 ***Middle Columbia River Salmon and Steelhead***

15223 Middle Columbia River Spring-Run Chinook Salmon

15224 See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River
15225 Spring-Run Chinook Salmon.

15226 *Summary of Key Effects*

15227 Middle Columbia River spring-run Chinook salmon would likely experience lower juvenile
15228 survival, with small increases in travel time and powerhouse encounters. Lower TDG would
15229 benefit both juvenile and adult fish, and adult migration would be increased with lower fallback
15230 and delays due to spill. Overall abundance under MO2 would likely be less than No Action
15231 Alternative due to juvenile effects.

15232 *Juvenile Fish Migration/Survival*

15233 See upper Columbia River spring-run Chinook salmon analysis as a surrogate for juvenile middle
15234 Columbia River spring-run Chinook salmon. Under MO2, surrogate analysis results predict CRS
15235 operational changes may result in lower survival, higher travel times, and increased
15236 powerhouse passage events on juvenile middle Columbia River Chinook.

15237 Measures described in the Common Effects section that refer to the lower four projects in the
15238 Columbia River would apply to middle Columbia River spring-run Chinook salmon. Middle
15239 Columbia River juvenile salmon would typically experience higher absolute survival than upper
15240 Columbia River spring-run Chinook salmon because they don't experience the higher mortality
15241 associated with the Columbia River from Chief Joseph Dam downstream to McNary Dam, but
15242 the percent change in juvenile survival would be similar because they experience the same CRS
15243 projects between McNary and Bonneville dams.

15244 *Adult Fish Migration/Survival*

15245 See upper Columbia River spring-run Chinook salmon analysis as a surrogate for adult migration
15246 and survival of middle Columbia River spring-run Chinook salmon. As described in Common
15247 Effects, lower spill may increase the upstream migration success of middle Columbia River
15248 spring-run Chinook salmon by reducing fallback and delays. Under MO2, decreased juvenile
15249 survival would likely result in reduced abundance of adult returns to the spawning grounds.

15250 Middle Columbia River Steelhead

15251 Refer to Upper Columbia River steelhead analysis as a surrogate for Middle Columbia River
15252 steelhead.

15253 *Summary of Key Effects*

15254 Juvenile middle Columbia River steelhead survival would be improved by structural measures
15255 but decreased overall by operations. The portion of the middle Columbia River steelhead that
15256 do not pass McNary or John Day dams (e.g., Deschutes MPG) would have better survival than
15257 the ones that encounter all four Columbia River dams, including two of the dams considered
15258 with fish screens removed. Adult migration conditions and kelt survival would increase but
15259 overall abundance may be lower.

15260 *Juvenile Fish Migration/Survival*

15261 Populations of middle Columbia River steelhead distributed between the Deschutes and Walla
15262 Walla Rivers pass two to four dams in the lower Columbia on their downstream outmigration to
15263 the ocean. Upper Columbia River steelhead modeling results were used as a surrogate for
15264 middle Columbia River steelhead (refer to Section 3.5.3.4). Under MO2, modeling results
15265 predicted that survival from McNary to Bonneville would experience minor decreases, although
15266 populations that only pass two dams would likely see a smaller decrease, when compared to No
15267 Action Alternative, due to the removal of fish screens at McNary and John Day which would not
15268 affect those populations with natal streams below John Day Dam. Increased powerhouse
15269 passage events were also indicated by the model and would reduce juvenile survival.
15270 Operational and structural measures contributing to this decrease are discussed in Common
15271 Effects section.

15272 *Adult Fish Migration/Survival*

15273 Under MO2, lower spill would increase adult migration success compared to the No Action
15274 Alternative. Structural measures designed for juvenile fish passage improvements such as
15275 increased surface passage would also improve survival of kelts. However, the decrease in
15276 juvenile survival metrics may result in fewer returning adults. Refer to upper Columbia River
15277 steelhead analysis as a surrogate for middle Columbia River steelhead.

15278 **Snake River Salmon and Steelhead**

15279 Snake River Spring/Summer-Run Chinook Salmon

15280 *Summary of Key Effects*

15281 Juvenile survival of in-river migrating fish would be lower than the No Action Alternative,
15282 though the models disagree somewhat on the magnitude of changes. MO2 would increase
15283 transportation of juvenile fish. The increased survival and faster travel time for this transported
15284 component of juveniles would help offset survival decreases of in-river fish when considered in
15285 the life cycle because more smolts would arrive at Bonneville Dam. The predictions of ocean
15286 survival and subsequent returns to the Columbia River system varies by model. The NWFSC
15287 LCM predicts slightly higher returns because more smolts would arrive at Bonneville Dam
15288 sooner, thus a higher number would survive the ocean phase and return. CSS predicts the
15289 benefit of transported juveniles would increase the number of smolts arriving at Bonneville, but
15290 lower ocean survival, likely due to increased latent mortality from the system experience. The
15291 CSS model ultimately predicts far fewer fish returning to spawning grounds compared to the No
15292 Action Alternative.

15293 *Juvenile Fish Migration/Survival*

15294 This ESU migrates through the Snake and Columbia Rivers downstream past the eight CRS
15295 projects, four on the Snake River, and four on the lower Columbia River. Structural and
15296 operational measures described in the Common Effects section that describe changes at all of
15297 these dams would apply to these fish. This includes structural measures designed to reduce the
15298 proportion of smolts passing through powerhouse routes and increase survival of smolts that
15299 do pass through the turbines, as well as measures to improve power generation that may
15300 increase smolt passage through these routes. Transport of smolts from the lower Snake River
15301 Projects would increase, but the effects of transportation from McNary Dam were not
15302 qualitatively evaluated by either the CSS or COMPASS models. See the Common Effects section
15303 for details.

15304 For Snake River spring-run/summer-run Chinook salmon, both models indicated a decrease in
15305 juvenile survival and increased travel time and more powerhouse passages, but vary on the
15306 magnitude of change. TDG modeling indicates lower reach average exposure for juveniles.
15307 Table 3-82 displays the juvenile metrics for MO2 predicted by each of the models.

15308 **Table 3-82. Juvenile Model Metrics for Snake River Spring/Summer-Run Chinook Salmon**
15309 **under Multiple Objective Alternative 2**

Metric (Model)	NAA	MO2	Change from NAA	% Change
Juvenile Survival (COMPASS)	50.4%	50.1%	-0.3%	-1%
Juvenile Survival (CSS)	57.6%	53.7%	-3.9%	-7%
Juvenile Travel Time (COMPASS)	17.7 days	18.3 days	+0.6 days	+3%
Juvenile Travel Time (CSS)	15.8 days	17.5 days	+1.7 days	+11%

Metric (Model)	NAA	MO2	Change from NAA	% Change
% Transported from Snake River (COMPASS)	38.5%	47.4%	+8.9%	+23%
% Transported from Snake River (CSS)	19.2%	33.8%	+14.6%	+76%
Transport: In-River Benefit Ratio (CSS)	0.86	1.18	+0.32	+37%
Powerhouse Passages (COMPASS)	2.25	3.02	+0.77	+34%
Powerhouse Passages (CSS)	2.15	3.48	+1.33	+62%
TDG Average Exposure (TDG Tool)	115.1% TDG	112.8% TDG	-2.3% TDG	-2%

15310 As described in Common Effects, the measures to increase juvenile fish transportation and
 15311 decrease spill would result in more juveniles transported than the No Action Alternative.
 15312 COMPASS, which uses only wild fish to assess transport, indicates the percentage of Snake River
 15313 spring Chinook transported would increase from 38.5 percent in the No Action Alternative to
 15314 47.4 percent in MO2. CSS includes hatchery and wild fish both in the model and predicts 19.2
 15315 percent of all smolts would be transported under the No Action Alternative but increase to 33.8
 15316 percent under the No Action Alternative. CSS also predicts the benefit of being transported (the
 15317 Transport: In-River Benefit Ratio) would increase from below one under the No Action
 15318 Alternative to 1.18 under MO2. This means that, on average throughout the transport season,
 15319 under the No Action Alternative fish left in-river would have overall better survival odds, but
 15320 under MO2, it would be more beneficial to be transported. Neither model accounts for changes
 15321 in proportion of the run that would be transported nor the additional effects if McNary Dam
 15322 was used as an additional collection point. Further discussion of effects of transport later in the
 15323 life cycle is in the following section on adult fish migration and survival.

15324 *Adult Fish Migration/Survival*

15325 The structural measure in MO2 to install pumping systems at Ice Harbor and Lower
 15326 Monumental would benefit adult Snake River spring-run/summer-run Chinook salmon passage
 15327 upstream if cooler water is available in the forebays. The reduced spill in MO2 may add benefit
 15328 for adult migration with lower fallback rates, since fallback for this ESU has been associated
 15329 with higher flow and higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). The
 15330 fish that fell back were significantly less likely to reach their spawning areas compared to fish
 15331 that never fell back.

15332 The NWFSC LCM results indicated a very small increase in overall SARs (+0.02 percent) and that
 15333 there would be an average of 11 percent increase in median adult abundances across all the
 15334 Snake River spring-run/summer-run Chinook populations modeled relative to the No Action
 15335 Alternative. CSS model results, however, indicate reduced SARs (-0.6 percent) and large
 15336 decreases in abundances (-43 percent average, with a range among populations in the Grande
 15337 Ronde/Imnaha major population group of -38 percent to -55 percent). These decreases are
 15338 largely driven by a large decrease in ocean survival (2.8 percent in MO2, compared to 3.6
 15339 percent in the No Action Alternative). See Table 3-83 for a summary of model outputs.

15340 **Table 3-83. Multiple Objective Alternative 2 Adult Model Metrics for Snake River**
15341 **Spring/Summer-Run Chinook Salmon**

Metric (Model)	NAA	MO2	Change from NAA	%Change
LGR-BON SARs (NWFSC LCM)	0.88%	0.90%	+0.02%	+3%
LGR-BON SARs (CSS)	2.0%	1.4%	-0.6%	-30%
Abundance of South Fork and Middle Fork Salmon River representative populations (NWFSC LCM)	2,351	2,602	+251	+11%
Abundance of representative Grande Ronde/Imnaha River populations (CSS) ¹	6114	3508	-2606	-43%

15342 ¹CSS provided results for six populations in the Grande Ronde/Imnaha Major Population Group. The absolute
15343 values represent those populations only; the percent change is considered indicative of the Snake River ESU for the
15344 purpose of comparing between MOs.

15345 The differences in model assumptions and the resulting predictions discussed in the methods
15346 section (3.5.3.1) are applicable in understanding MO2 effects on Snake River spring/summer-run
15347 Chinook salmon. To calculate the smolt to adult return rate for the population, the NMFS LCM
15348 uses input metrics from COMPASS results such as juvenile survival and travel timing. The model
15349 continues to estimate a population’s survival once the individuals pass Bonneville Dam, enter
15350 the ocean, rear and grow for several years, and then return as adults to Bonneville Dam. The
15351 model then adds an adult migration module that starts with the number of adults reaching
15352 Bonneville dam and computes expected survival on migration upstream to spawning grounds in
15353 the upper Snake River basin. It is important to remember that the juvenile survival indicated in
15354 the COMPASS metrics in the juvenile survival table applies to in-river travelling smolts only.
15355 Based on previous research, transported smolts are estimated to have a survival rate of 98
15356 percent from Lower Granite to Bonneville, compared around 50 percent for in-river smolts. In
15357 MO2, the higher proportion of transported fish results in more smolts experiencing the higher
15358 transported survival rate.

15359 Similarly, CSS also indicates a benefit to transported fish in this alternative when comparing the
15360 SARs between the two groups, likely due to decreased survival of in-river migrating fish in MO2.

15361 One of the drivers of the LCM ocean survival module is the arrival timing of smolts to the ocean;
15362 because more smolts are transported, and transported fish have better initial survival rates and
15363 much faster arrival timing than in-river fish. The results from the model are increased abundance
15364 of adults arriving back to Bonneville Dam, as indicated by an increase in SAR. Timing is also
15365 important; generally speaking, fish transported later in the season experience better SARs than
15366 in-river fish. Earlier in the season, there is generally a higher benefit to in-river travel. Seasonal
15367 changes can be driven by reduced in-river survival due to increased predation and thermal
15368 stress.

15369 The NWFSC LCM indicates a higher abundance of fish returning to spawning grounds because
15370 higher transportation rates increase SARs, especially later in the season, and those adults then
15371 experience higher migration success from Bonneville to spawning grounds. It is important to
15372 note, however, that the higher rate of transported smolts would result in more adults straying to
15373 different populations than their origin.

15374 One major difference between the models is in the ocean survival module. CSS incorporates
15375 data indicating latent mortality that is dependent on the hydrosystem experience of each
15376 smolt. For MO2, ocean survival was predicted to decrease from 3.6 percent under the No
15377 Action Alternative to 2.8 percent. Latent mortality associated with powerhouse passage rates
15378 and increased travel time in the CSS model are the likely drivers in the different SAR predictions
15379 between the two models.

15380 Snake River Steelhead

15381 *Summary of Key Effects*

15382 Juvenile survival of in-river migrating fish would be lower than the No Action Alternative; both
15383 models indicate decreases, though magnitude varies between the models. MO2 would increase
15384 transportation of juvenile fish; the increased survival and faster travel time for this transported
15385 component of juveniles would help offset survival decreases of in-river fish when considered in
15386 the life cycle. More smolts would arrive at Bonneville Dam. CSS predicts the benefit of
15387 transported juveniles would be higher but predicts lower SARs. Neither model was able to
15388 predict abundance. Adults would likely express higher rates of straying.

15389 *Juvenile Fish Migration/Survival*

15390 This DPS migrates through the Snake and Columbia Rivers downstream past eight CRS projects,
15391 four on the Snake River, and four on the lower Columbia River. Structural and operational
15392 measures described in the Common Effects section that describe changes at these dams would
15393 apply to these fish. This includes structural measures designed to reduce the proportion of
15394 smolts passing through powerhouse routes and increase survival of smolts that do pass through
15395 the turbines, as well as measures to improve power generation that may increase smolt
15396 passage through these routes at some dams. Transport of smolts from the lower Snake River
15397 Projects would be increased but the effects of transportation from McNary Dam were not
15398 evaluated by either the CSS or the COMPASS models. See the Common Effects section for
15399 details. For Snake River steelhead, both models indicated a decrease in juvenile survival,
15400 increased travel time and more powerhouse passages, but vary somewhat on the magnitude of
15401 change. TDG modeling indicates lower reach average exposure for juveniles, and a reduction in
15402 juvenile mortality associated with TDG exposure. Table 3-84 displays a summary of the juvenile
15403 metrics:

15404 **Table 3-84. Multiple Objective Alternative 2 Juvenile Model Metrics for Snake River Steelhead**

Metric (Model)	NAA	MO2	Change from NAA	% Change
Juvenile Survival (COMPASS)	42.7%	40.2%	-2.5%	-6%
Juvenile Survival (CSS)	57.1%	44.4%	-12.7%	-22%
Juvenile Travel Time (COMPASS)	16.4 days	16.9 days	+0.5 days	+3%
Juvenile Travel Time (CSS)	16.2 days	17.2 days	+1.0 days	+6%
% Transported (COMPASS)	39.7%	47.7%	+8.0%	+20%
% Transported (CSS)	N/A			
Transport: In-River Benefit Ratio (CSS)	1.41	2.23	+0.82	+58%

Metric (Model)	NAA	MO2	Change from NAA	% Change
Powerhouse Passages (COMPASS)	1.73	2.26	+0.53	+31%
Powerhouse Passages (CSS)	1.96	3.26	+1.30	+66%
TDG Average Exposure (TDG Tool)	115.1% TDG	112.7% TDG	-2.4% TDG	-2%

15405 As described in Common Effects, the measure to increase juvenile fish transportation and
 15406 decreased spill would result in more juveniles transported than the No Action Alternative.
 15407 COMPASS, considering only wild fish in the equation, indicates the percentage transported
 15408 would increase from about 40 percent to about 48 percent. CSS did not provide an estimate of
 15409 proportion transported, but predicts the Transport: In-River Benefit Ratio would increase from
 15410 1.41 under the No Action Alternative to 2.23 under MO2. Steelhead experience higher benefits
 15411 from transportation than Snake River spring-run/summer-run Chinook salmon.

15412 On average throughout the transport season, under the No Action Alternative transported fish
 15413 would have long-term survival advantages over in-river fish, and under MO2 the difference in
 15414 this metric would be larger (i.e., higher survival benefits for transported fish). Neither of the
 15415 models account for changes in the proportion of the run that would be transported, nor the
 15416 additional effects if McNary Dam was used as an additional collection point. Further discussion
 15417 of effects from transport later in the life cycle is in the following section on adult fish migration
 15418 and survival.

15419 *Adult Fish Migration/Survival*

15420 CSS cohort modeling estimated smolt to adult return (SAR) estimates from Lower Granite to
 15421 Bonneville would decrease from 1.8 percent under the No Action Alternative to 1.2 percent in
 15422 MO2. Lower SARs would indicate that total abundance of adult steelhead would decrease as
 15423 well. No other life cycle modeling was available.

15424 Qualitatively speaking, the benefit of transport would be higher (i.e., resulting in higher SARs
 15425 for transported fish) in MO2, and more fish would be transported as juveniles, which could
 15426 increase the ocean survival of steelhead, but it is unknown if the benefit of transport would
 15427 sufficiently overcome the reduction in in-river survival to increase or decrease adult returns.
 15428 Conversely, CSS modeling predicted decreased ocean survival (2.5 percent compared to 2.9
 15429 percent in the No Action Alternative) that would result in lower abundances of adult returns.
 15430 Higher proportions of fish that were transported as juveniles may increase the rate of straying
 15431 in adult returns. Keefer and Caudill (2012) reported a 2 to 7 percent stray rate for non-
 15432 transported steelhead vs. 7 to 9 percent among transported fish.

15433 Transportation has been shown to provide a benefit to steelhead. Full life cycle modelling from
 15434 COMPASS was not available, however, modelled data shows that MO2 would increase
 15435 transportation rates by 8 percent and result in increased return rates at Lower Granite Dam, in
 15436 the absence of latent mortality effects predicted in the CSS model.

15437 Lower spill levels during April and May would likely result in lower survival rates for adult
 15438 steelhead falling back through dams and kelts migrating downstream, as more adults would use

- 15439 powerhouse passage routes that are generally associated with lower survival rates
15440 (Normandeau et al. 2014; Ham et al. 2012).
- 15441 Snake River Coho Salmon
- 15442 See Snake River spring/summer-run Chinook salmon as a surrogate for juvenile Snake River
15443 coho salmon and Snake River fall-run Chinook as a surrogate for adult Snake River coho salmon.
- 15444 *Summary of Key Effects*
- 15445 Juvenile Snake River coho salmon survival would decrease in MO2, but the models predict
15446 different magnitudes of decrease for the surrogate species (Snake River spring/summer-run
15447 Chinook salmon). Juveniles would experience more powerhouses and have slower migration
15448 times, and more juveniles would be transported than under the No Action Alternative. These
15449 transported juveniles would experience higher survival than in-river fish.
- 15450 *Juvenile Fish Migration/Survival*
- 15451 Refer to MO2 Snake River juvenile spring Chinook results as a surrogate for Snake River Coho
15452 Salmon.
- 15453 *Adult Fish Migration/Survival*
- 15454 Abundance of Snake River coho salmon was not modeled, but some inferences can be made
15455 from life cycle modeling of Snake River spring/summer-run Chinook salmon. This ESU was used
15456 as a surrogate for Snake River coho salmon juvenile metrics, indicating more coho salmon
15457 would be destined for transport than in the No Action Alternative. The net effect of these
15458 factors under MO2 on coho salmon returns is uncertain. If greater survival of transported fish
15459 was offset by decreased juvenile survival, there could be minor net increase of adults. If latent
15460 effects of powerhouse encounters decrease ocean survival, there would be fewer adults.
- 15461 Snake River Sockeye Salmon
- 15462 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake
15463 River sockeye salmon.
- 15464 *Summary of Key Effects*
- 15465 The key effects of MO2 are the slightly slower migration time that puts juvenile sockeye at
15466 greater risk of predation. Although the proposal for transporting juveniles might improve
15467 survival for that life stage, this action is likely to cause a greater rate of fallback and straying of
15468 adults on their upstream migration compared to the No Action Alternative. Overall abundance
15469 of returning fish would depend on how increased transport, later arrival timing, and any latent
15470 effects from increased powerhouse encounters affect ocean survival.

15471 *Juvenile Migration/Survival*

15472 MO2 is expected to result in a slightly slower migration time for juvenile sockeye
15473 (approximately one day) based on modeling results for surrogate species juvenile Snake River
15474 spring-run Chinook because they migrate downstream at approximately the same time of year.
15475 Travel rates for juvenile sockeye are typically faster than yearling Chinook and therefore the use
15476 of this surrogate may provide a conservative estimate. See upper Columbia River sockeye
15477 salmon (Section 3.5.3.2) for additional travel time information compared to yearling Chinook
15478 salmon that migrate through the middle Columbia River. Spill rates under MO2 may contribute
15479 to a slower travel time, and the proportion of fish going through the powerhouse would be
15480 higher.

15481 It is assumed that slower travel times result in lower survival rates due to greater swimming
15482 effort and longer duration of exposure to predators. Predation by fish in reservoirs would
15483 continue to occur at the same rate as in the No Action Alternative based on water temperature,
15484 which is used as an index to estimate predator activity. However, based on the slightly slower
15485 travel time as described above, juvenile sockeye salmon would have a slightly longer exposure
15486 time for risk of predation in MO2. Among bird predators, their nesting population is expected
15487 to be the same as in the No Action Alternative, but again the slower travel time would put the
15488 juvenile sockeye at greater risk of exposure.

15489 *Adult Migration/Survival*

15490 In MO2, the surrogate species for Snake River sockeye salmon, Snake River spring/summer-run
15491 Chinook salmon, would have approximately a 10 percent increased rate of transportation as
15492 juveniles compared to the No Action Alternative. This substantial increase in transport would
15493 likely lead to a proportional increase in the adverse effects for the adult fish that were
15494 transported as juveniles. These adverse effects would include impaired ability to find their birth
15495 streams (i.e., homing ability), migration delay, increased fallback, and straying. This impaired
15496 homing ability may contribute to higher un-intentional catch during other fisheries in the lower
15497 Columbia River, and can be lethal during warm water years (NMFS 2015).

15498 The summer water temperatures in the river during the upstream migration would not change
15499 from the No Action Alternative, nor would the percentage of days in which the ladder
15500 temperature would be more than 2 degrees Celsius warmer than the river temperature.
15501 However, Dworshak Reservoir operations would be affected such that the probability of
15502 refilling the reservoir would be lower, resulting in higher risk of not having enough water in the
15503 reservoir to provide summer cooling water. In MO2, fewer days per year would have TDG over
15504 120 and 125 percent at all projects. This change is substantial enough that MO2 would have
15505 fewer adverse effects from TDG on Snake River sockeye compared to the No Action Alternative.
15506 The other important water quality parameters of suspended sediment and DO would have no
15507 change compared to the No Action Alternative.

15508 Snake River Fall-Run Chinook Salmon

15509 *Summary of Key Effects*

15510 Although the proposal for transporting juveniles might improve survival for that life stage, this
15511 action is likely to cause a greater rate of fallback and straying as adults on their upstream
15512 migration compared to the No Action Alternative.

15513 *Larval Development/Juvenile Rearing*

15514 None of the measures of MO2 would change the substrate sizes or distribution in the spawning
15515 areas or expand suitable spawning areas; therefore, this alternative is expected to have the
15516 same larval development and juvenile rearing habitat conditions as the No Action Alternative.
15517 The same is true for river depths in the spawning areas; no change is anticipated for eggs
15518 incubating in the gravel. MO2 would not have a measurable difference compared to the No
15519 Action Alternative for juvenile Chinook rearing in reservoirs; therefore, their visual cover from
15520 predation would not change.

15521 *Juvenile Migration/Survival*

15522 None of the measures in MO2 would affect turbidity during juvenile Chinook outmigration
15523 months of May through July. The combination of structural measures intended to improve
15524 juvenile survival and operational and structural measures that would decrease survival would
15525 likely result in a net decrease in juvenile survival. See the Common Effects section of MO2 for a
15526 description of these measures.

15527 *Adult Migration/Survival*

15528 Adult straying rate is expected to increase in MO2 due to the operational measure to maximize
15529 transport. This would reduce the total number of adult fall-run Chinook returning to the Snake
15530 River because of the expected increase in rate of straying and fallback. Depending on the
15531 overall transport to in-river benefit ratio, this may cause a decrease in adult returns to
15532 spawning areas of the Snake River basin.

15533 River water temperatures during the upstream migration period are expected to be the same
15534 as in the No Action Alternative. The same is true for the temperature difference between the
15535 river and the fish ladders. However, the probability of Dworshak filling would be lower in MO2,
15536 resulting in more years where the volume of water required for cooling the Snake River with
15537 Dworshak water would not be sufficient. This would affect the early part of the Snake River fall
15538 Chinook salmon run. There would be no change to sediment concentrations or DO levels from
15539 any measures in MO2 during the adult migration period.

15540 **Lower Columbia River Salmon and Steelhead**

15541 Lower Columbia River Chinook Salmon

15542 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower
15543 Columbia River Chinook salmon.

15544 *Summary of Key Effects*

15545 Juvenile survival and travel time would be similar to the No Action Alternative, with slight
15546 increases in modeled metric of surrogate species (Snake River spring/summer-run Chinook
15547 salmon), but slight decreases in qualitative analysis. Adult migration and survival would be
15548 expected to be higher with lower flows, lower spill, and lower TDG.

15549 Results (and change from the No Action Alternative) for metrics for Lower Columbia River
15550 Chinook salmon:

- 15551 • Negligible increase in juvenile project survival at Bonneville Reservoir and Dam (see
15552 surrogate species Snake River spring-run/summer-run Chinook) = (+0.5 percent)
- 15553 • Bonneville outflows, April-June = (-1 percent to -2 percent)
- 15554 • Bonneville outflows, August-September = (August: -1 percent to -2 percent, September: +1
15555 percent to +2 percent)
- 15556 • Spill, Bonneville = April (-42 to -28kcfs), May (-40kcfs), August (-87kcfs)
- 15557 • Temperature, The Dalles, days exceeding state standard = 71 days (0 days)
- 15558 • Temperature, Bonneville, days exceeding state standard = 57 days (-1 day)
- 15559 • TDG, The Dalles, days exceeding state standard = 11 days (-22 days)
- 15560 • TDG, Bonneville, days exceeding state standard = 46 days (-18 days)

15561 *Juvenile Fish Migration/Survival*

15562 Five of the 32 populations of Lower Columbia River Chinook salmon pass Bonneville Dam on
15563 their downstream outmigration to the ocean. Modeling was not available for this ESU so
15564 juvenile survival at Bonneville Dam of Snake River spring-run/summer-run Chinook salmon was
15565 used as a surrogate of juvenile survival for the proportion that pass this project. COMPASS
15566 modeling under MO2 predicted similar juvenile survival through the Bonneville Dam compared
15567 to No Action Alternative, which is consistent with the expectation that lower spill at Bonneville
15568 Dam could result in slightly higher survival.

15569 Outflows can influence juvenile outmigration if changes in flows are enough to noticeably affect
15570 travel time, and therefore survival. Hydrology modeling predicts spring-run and late-fall-run fish
15571 would experience outflows about 1 to 2 percent lower than the No Action Alternative. Fall-run
15572 fish outmigrate in late summer and may see flows 1 to 2 percent lower than the No Action
15573 Alternative except in September when flows would be 1 to 2 percent higher than the No Action

15574 Alternative. Changes of this magnitude would likely be imperceptible on effects to juvenile
15575 outmigration. Likewise, water quality modeling indicated there would not be a perceptible
15576 change in temperature in the lower river with MO2 operations, and TDG would be lower than
15577 under the No Action Alternative.

15578 *Adult Fish Migration/Survival*

15579 MO2 does not include the structural measure to modify the upper ladder serpentine sections at
15580 Bonneville Dam seen in other MOs. Lower spill in MO2 would decrease fallback rates and lower
15581 TDG could reduce impacts on adults. Hydrology and water quality modeling predicts flows and
15582 temperatures that could affect lower Columbia River Chinook salmon adult migration and
15583 survival would be similar to the No Action Alternative.

15584 Lower Columbia River Steelhead

15585 Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

15586 *Summary of Key Effects*

15587 Juvenile survival would be similar to or slightly lower than the No Action Alternative, with similar
15588 modeled dam survival but slightly reduced flows in March and slower travel time. Adult
15589 migration of a portion of the winter run could be decreased slightly with higher winter flows, and
15590 survival of kelts would be lower with reduced spill, although lower TDG may increase survival.

15591 MO2 results (and change from the No Action Alternative) for metrics for Lower Columbia River
15592 steelhead:

- 15593 • Negligible decrease in juvenile project survival, Bonneville Reservoir and Dam (see Snake
15594 River steelhead [used as a surrogate]) = (-0.1 percent)
- 15595 • Bonneville outflows, March = (-4 percent), April-June = (-1 percent to -2 percent)
- 15596 • Bonneville outflows, November-December = (+3 to +7 percent), otherwise (+/- 0 to 2
15597 percent)
- 15598 • Spill, Bonneville = April through June = (-28kcfs to -39kcfs), August (-87kcfs)
- 15599 • Temperature, The Dalles, days exceeding state standard = 71 days (0 days)
- 15600 • Temperature, Bonneville, days exceeding state standard = 57 days (-1 day)
- 15601 • TDG, The Dalles, days exceeding state standard = 11 days (-22 days)
- 15602 • TDG, Bonneville, days exceeding state standard = 46 days (-18 days)

15603 *Juvenile Fish Migration/Survival*

15604 Four of the 23 populations of Lower Columbia River steelhead pass Bonneville Dam on their
15605 downstream outmigration to the ocean. Modeling was not available for Lower Columbia River
15606 steelhead, so juvenile survival at Snake River steelhead was used as a surrogate of juvenile

15607 survival through the Bonneville project (pool and dam) for this portion of the DPS. COMPASS
15608 modeling predicts a negligible decrease or similar juvenile survival under MO2 compared to the
15609 No Action Alternative. Four percent lower outflows in March and generally lower spill may
15610 reduce juvenile migration success; the remainder of the outmigration period would be similar (-
15611 1 percent to -2 percent) to the No Action Alternative. Temperatures would be similar to the No
15612 Action Alternative, and TDG would be lower with reduced spill.

15613 *Adult Fish Migration/Survival*

15614 MO2 does not include structural measures for adult passage improvements for Lower Columbia
15615 River steelhead. Under MO2, lower spill through spring and summer and spill reduction in
15616 August would lower survival rates for adult kelts, but generally reduce adult fallback and delay.
15617 A higher proportion of kelts moving downstream would pass Bonneville Dam via turbines,
15618 which have lower survival rates than spill. Winter run steelhead migrating in December would
15619 experience flows about 7 percent higher than the No Action Alternative. Otherwise, adult
15620 passage conditions due to flows would be similar to the No Action Alternative. Temperatures
15621 would be similar to the No Action Alternative, and adult fish would generally experience lower
15622 TDG, with 18 to 22 more days under the state water quality standard than the No Action
15623 Alternative.

15624 Lower Columbia River Coho Salmon

15625 See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower
15626 Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult
15627 Lower Columbia River coho salmon.

15628 *Summary of Key Effects*

15629 Lower Columbia River coho salmon juvenile survival and adult migration factors would be
15630 similar or slightly better than the No Action Alternative based on surrogate information.
15631 Juvenile survival would have negligible to minor decreases. TDG exposure would be lower, and
15632 temperatures would be cooler around Bonneville Dam.

15633 *Juvenile Fish Migration/Survival*

15634 Juvenile survival of Lower Columbia River coho salmon passing Bonneville Dam, based upon
15635 project survival of Snake River spring/summer-run Chinook salmon as a surrogate, would have
15636 negligible to minor decreases in MO2, relative to No Action Alternative. Generally speaking,
15637 lower spill at Bonneville Dam results in higher survival through the dam. Refer to Snake River
15638 spring-run Chinook for surrogate information (Section 3.5.3.5).

15639 *Adult Fish Migration/Survival*

15640 Lower Columbia River coho salmon adults are similar in upstream migration characteristics to
15641 Snake River fall-run Chinook salmon and were used as a surrogate; Snake River fall-run Chinook
15642 salmon were analyzed in workshops using modeled water quality and hydrology data. The

15643 results of modeled water quality and hydrology data depicted that water temperatures around
15644 Bonneville Dam may be slightly cooler under MO2 compared to the No Action Alternative and
15645 could benefit upstream migrating Lower Columbia River coho salmon. MO2 operational
15646 changes would not change the number of days when lower Columbia River water temperatures
15647 in reservoirs would exceed 20°C and/or fish ladder temperature differentials exceed 2°C, cause
15648 adult salmon to stop or delay migration, increase fallback at dams, and increase susceptibility to
15649 disease Refer to Snake River fall-run Chinook for surrogate information in Section 3.5.2.4.

15650 Lower Columbia River Chum Salmon

15651 Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia
15652 River chum salmon juvenile dam passage.

15653 *Summary of Key Effects*

15654 MO2 operations would result in more difficulty in meeting chum flows, with a 3 percent
15655 increase, compared to the No Action Alternative, of years where the flows could not be met
15656 downstream of Bonneville Dam without additional drafting of Grand Coulee. Juvenile
15657 outmigration could be slower due to decreased outflows in March, and the small proportion
15658 that pass Bonneville Dam would experience negligible increased survival at the dam. Adult
15659 migration and survival would likely be similar to the No Action Alternative.

15660 *Larval Development/Juvenile Rearing*

15661 How operations under MO2 affect the ability of Grand Coulee to provide winter flows to
15662 protect chum redds and provide sufficient access to habitat was calculated using hydrology
15663 modeling. Under MO2, chum flows would be met in 89 percent of years, compared to 92
15664 percent of years in the No Action Alternative. In years when additional releases from Grand
15665 Coulee for chum would be needed, the average additional volume needed would be
15666 0.12 million acre-feet (Maf). MO2 would result in 3 percent more years where chum flows
15667 would not be met, and agencies would thus have to decide whether to increase risk to chum
15668 eggs or reduce spring augmentation flows for spring migrating juvenile salmon.

15669 Maintaining water saturation of 105 percent TDG or less from November 1 to April 30 appears
15670 to provide a sufficient level of protection to chum salmon eggs and sac fry incubating in the
15671 gravel downstream of Bonneville Dam in the Ives/Pierce Island Complex. In MO2, chum sac fry
15672 would be exposed to TDG above 105 percent in four out of the 80-year record modeled, all in
15673 the mid- to late April timeframe. This is one year less than the No Action Alternative where this
15674 TDG threshold would be exceeded.

15675 *Juvenile Fish Migration/Survival*

15676 Chum salmon only encounter one CRS project, Bonneville Dam; therefore, none of the
15677 structural measures described in common effects would apply to these fish, and only a small
15678 proportion of spawning occurs above Bonneville Dam. As there is no direct estimate of

15679 Bonneville Dam survival specific to juvenile chum, juvenile model metrics for Snake River
15680 spring-run/summer-run Chinook salmon are used as a surrogate to estimate any change in
15681 juvenile survival for the portion that pass Bonneville.

15682 Bonneville Dam outflows would be about 4 percent lower than the No Action Alternative in
15683 March, when chum juveniles begin outmigration. This could result in a minor increase in their
15684 travel time, thus increasing exposure to predation. Under MO2, COMPASS modeling of the
15685 surrogate species, Snake River spring/summer-run Chinook salmon, indicates that CRS
15686 operational changes are expected to result in negligible increases in survival for juvenile fish
15687 passing downstream of Bonneville Dam compared to the No Action Alternative. MO2 would not
15688 change the outmigration conditions for juvenile chum that spawn below Bonneville Dam, other
15689 than they may experience lower TDG than under the No Action Alternative.

15690 *Adult Fish Migration/Survival*

15691 Most chum spawn downstream of Bonneville Dam. Upstream migration of chum into the
15692 Columbia River occurs in October and November. Bonneville Dam average monthly outflows
15693 would be about 3 percent lower than the No Action Alternative in October, while in November
15694 they would be about 3 percent higher than the No Action Alternative. Adults spawning in
15695 December would encounter outflows about 7 to 13 percent higher than the No Action
15696 Alternative.

15697 **Other Anadromous Fish**

15698 *Pacific Eulachon*

15699 Summary of Key Effects

15700 Eulachon would continue to migrate into the Columbia River from November through March,
15701 with specific dates of migration and spawning based on a variety of environmental factors
15702 including temperature, high tides, and ocean conditions (NMFS 2017). Modeled data for MO2
15703 (based on the period of record for Bonneville tailwater temperatures) indicate that
15704 temperatures would not be substantially different from the No Action Alternative (all
15705 temperatures would be within 0.6 degrees of the No Action Alternative.) Spawning locations
15706 and substrate conditions would not be expected to differ from the No Action Alternative.

15707 Compared to the No Action Alternative, MO2 would have no change in the time between the
15708 peak spawning runs, egg development, and larval emergence. The spring freshet that disperses
15709 larvae to adequate food sources would continue to be highly variable, with an average of 168
15710 days between spawning temperature triggers and peak flows (157 days in high flow years, and
15711 158 days in low flow years).

15712 Spring flow rates would be expected to be about 1 percent to 2 percent lower during
15713 outmigration compared to the No Action Alternative.

15714 Bird predation risk can be influenced by flow rates. Higher flows are linked to higher predation
15715 rates on eulachon, whereas at lower flows birds tend to switch to marine prey. Under MO2,
15716 there would be a minor change (2 to 6 percent) in all months and water year types (the change
15717 is low enough to be likely immeasurable). Higher flows in winter (November to January) could
15718 pose a minor increase in predation risk when the bulk of the eulachon run is migrating up the
15719 Columbia River.

15720 **Green Sturgeon**

15721 Summary of Key Effects

15722 The Columbia River use by green sturgeon is primarily foraging habitat for adults and subadults.
15723 Key effects of MO2 are focused on how flows and temperatures influence the cues for entering
15724 the Columbia River as well as the availability and distribution of food sources. Under MO2,
15725 flows in the area used by green sturgeon would be similar to the No Action Alternative (0
15726 percent to 2 percent variation). Modeled flows indicate flows could be slightly higher in
15727 September (+2 percent), and lower in October (-2 percent), which could result in minor shifts in
15728 location for feeding from downstream in September to further upstream in October.

15729 **Pacific Lamprey**

15730 Summary of Key Effects

15731 MO2 has several measures that are designed specifically to benefit lamprey. These measures
15732 are proposed structural improvements that include converting extended-length submersible
15733 bar screens to submersible bar screens, expanding the network of Lamprey Passage Structures
15734 to bypass impediments in fish ladders, changing the design for turbine cooling water strainers,
15735 replacing turbines for safer fish passage, and other physical modifications to reduce fish injury
15736 and mortality.

15737 Larval Development/Juvenile rearing

15738 MO2 has no measures that would either benefit or harm juvenile lamprey rearing. All ramping
15739 rates and dewatering issues would be the same in this alternative as for the No Action
15740 Alternative.

15741 Juvenile Migration/Survival

15742 A substantial amount of injuries and mortality can occur for outmigrating juveniles on their
15743 downstream migration including impingement on screens. Several measures would improve
15744 conditions and reduce injuries and losses. These measures are also in MO1 and their effects are
15745 described in more detail in the lamprey section in that alternative. Briefly, the measures and
15746 their anticipated effects would be:

- 15747 • Converting the extended-length submersible bar screens to submerged traveling screens
15748 would substantially reduce mortality due to impingement.

- 15749 • A new design of structure for exclusion of juvenile lamprey from cooling water strainer
15750 intakes would substantially reduce or eliminate this pathway of mortality.
- 15751 • Additional powerhouse surface passage at Ice Harbor and McNary Projects would change
15752 the dynamics of lamprey passage. A higher percentage of lamprey would be expected to
15753 pass via the surface routes instead of the turbines in relation to the No Action Alternative,
15754 but the overall relative effect to juvenile lamprey passage is unknown.
- 15755 • Replacing turbines at John Day Project with a newer design of turbine would improve
15756 conditions for fish passage and reduce the injury rate for lamprey.
- 15757 • Ceasing the installation of fish screens at Ice Harbor, McNary, and John Day Projects would
15758 eliminate the effects of lamprey impingement on screens.

15759 Because of the high degree of uncertainty surrounding how many juvenile lamprey are lost or
15760 injured on their downstream migration, it is difficult to quantify the improvement represented
15761 by all of the measures. For fish that encounter multiple dams on their migration downstream,
15762 reducing the total number of hazards would increase their probability for survival to adult life
15763 stage.

15764 Adult Migration/Survival

15765 Similarly, there are measures in MO2 that were also in MO1 and that improve adult lamprey
15766 passage. These include:

- 15767 • Expanding the network of lamprey passage structures would improve lamprey passage.
- 15768 • Modify the upper ladder serpentine flow control ladder sections at Bonneville Dam would
15769 reduce migration delays caused by baffles in this section.
- 15770 • Adding cooler water in the fish ladders at Lower Monumental and Ice Harbor would be
15771 expected to benefit lamprey because this has been successful at Little Goose and Ice
15772 Harbor.
- 15773 • Modifications to Lower Monumental include diffuser grate plating. This has been done at all
15774 other ladders except Lower Monumental and demonstrated slight benefits to lamprey
15775 passage.

15776 Each structural measure in MO2 that targets lamprey is intended to increase their dam passage
15777 efficiency either by getting fish to enter rather than turn back from the fishway, or to increase
15778 successful passage to continue migrating. See MO1 for more details on effects of these
15779 measures. Collectively they would provide incremental improvements to adult migration and
15780 survival.

15781 The overall expected improvements in lamprey passage efficiency should decrease
15782 susceptibility to physical stress and mortality, and shorter holding time would be beneficial to
15783 the fish. These structural measures for lamprey are expected to provide an incremental benefit
15784 to the population size and distribution of Pacific lamprey in the Columbia Basin. Compared to

15785 the No Action Alternative, all proposed structural measures to reduce losses would have
15786 benefits to the population and recruitment to the next generation. The combined effect of all
15787 proposed structural modifications would be a substantial improvement for lamprey survival and
15788 fitness. However, most of the water management and water supply operational measures have
15789 no benefit and might make migration conditions worse for juvenile lamprey compared to the
15790 No Action Alternative.

15791 ***American Shad***

15792 Summary of Key Effects

15793 No change is anticipated to juvenile shad because plankton communities and shoreline habitat
15794 would not change in MO2. The proportion of adult shad counted at Bonneville Dam that
15795 migrate upstream past McNary Dam is expected to increase under this alternative due to
15796 decreases in outflows during shad migration months.

15797 **RESIDENT FISH**

15798 **Region A**

15799 ***Kootenai River Basin***

15800 Summary of Key Effects

15801 MO2 would have the same key effects as the No Action Alternative. Discharges from Libby Dam
15802 would continue to have detrimental effects to fish species in the Kootenai River downstream of
15803 Libby Dam. Spring water temperatures would continue to be too cold for optimum
15804 development of some aquatic species. Spring flows would also continue to increase at a rate
15805 similar to the No Action Alternative, with ongoing delay and impaired productivity associated
15806 with inundated riparian and varial zone habitats in the river corridor from the dam to Kootenay
15807 Lake in British Columbia. These reduced flow rates would also continue to limit productivity and
15808 may adversely impact kokanee and their food sources downstream of Libby Dam.

15809 Under the MO2, cottonwood seedlings would continue to have variable survival depending on
15810 timing, stage and duration of spring flows, along with winter stage during the ensuing winter. In
15811 addition, the discharge regime from Libby Dam would not provide for successful burbot
15812 recruitment, and spring water temperatures would be too cold to allow for proper larval
15813 development.

15814 Habitat Effects Common to This Fish Community

15815 MO2 would not change water temperatures in the spring from those under the No Action
15816 Alternative. However, MO2 would provide deeper end-of-December drafts than the No Action
15817 Alternative, with deep drafts of 26.7 feet in some years that may enhance reservoir warming
15818 during the spring and early summer.

15819 Under MO2 there would be a lower rate of flow increase from Libby Dam between mid-March
15820 and mid-May than the No Action Alternative This decrease in flow rate under MO2 would result
15821 in a greater delay in commencement of river productivity than under the No Action Alternative.

15822 MO2 would decrease the potential for cottonwood and willow seeding and recruitment
15823 compared to the No Action Alternative. Under MO2, there would be fewer days when the
15824 winter peak stage does not exceed the seeding peak stage. There would also be a smaller
15825 difference in river elevation between the winter and spring peak stage at Bonners Ferry when
15826 compared to the No Action Alternative.

15827 MO2 would not differ from the No Action Alternative in the rate of recession of river stage at
15828 Bonners Ferry during the seeding season.

15829 Bull Trout

15830 Effects to bull trout under MO2 that differ from those of the No Action Alternative include
15831 lower minimum and maximum water levels at Lake Kooconusa, lower flows below Libby Dam,
15832 less habitat for adult bull trout, but more habitat for juvenile bull trout.

15833 Under MO2, Lake Kooconusa would be above elevation 2,450 feet for two more days than
15834 under the No Action Alternative. This short period would not be sufficient to have different
15835 effects on the Bull trout population than the No Action Alternative.

15836 The median minimum elevation of Lake Kooconusa under MO2 would be 11 foot lower than
15837 under the No Action Alternative, but the drier forecast years could be ten to twenty feet
15838 deeper. These elevations would increase the risk of annual dewatering and decrease benthic
15839 insect production, which could result in a decrease in bull trout growth and/or survival.
15840 However, in wet years, MO2 would provide a shallower draft and may be more beneficial to
15841 benthic insect production during those years. At the same time, the maximum elevation of Lake
15842 Kooconusa under MO2 would be 1 foot higher than under the No Action Alternative. This may
15843 result in slightly higher terrestrial insect deposition under MO2.

15844 Under MO2, Libby Dam would provide discharge of 20 kcfs or greater for two less days than
15845 under the No Action Alternative. These flows would be insufficient to mobilize or reshape
15846 tributary deltas that can prevent bull trout access during the late summer and early fall. MO2
15847 would have lower discharges than the No Action Alternative and would provide less usable
15848 habitat for adult bull trout, but more usable habitat for juvenile bull trout than the No Action
15849 Alternative.

15850 Kootenai River White Sturgeon

15851 On average, MO2 would provide one less day than the No Action Alternative when flows are
15852 greater than or equal to 30 kcfs at Bonners Ferry between May 15 and July 15. This reduction in
15853 the number of days with high flows would not differ biologically in the number of spawning
15854 adult Kootenai River white sturgeon that migrate to spawning habitat upstream of Bonners

15855 Ferry when compared to the No Action Alternative. However, in dry water years, flows would
15856 be more than 24 percent lower during this critical period and could reduce the spawning and
15857 recruitment of Kootenai River white sturgeon.

15858 Other Fish

15859 The median minimum elevation of Lake Koocanusa under MO2 would be one foot, but the drier
15860 forecast years could be ten to twenty feet lower. These conditions would have the same effects
15861 identified in the discussion above for bull trout.

15862 Under MO2, there would be fewer days when Libby Dam would provide a discharge of 20 kcfs or
15863 greater when compared to the No Action Alternative. In addition, the mean flow rate under MO2
15864 would be less than under the No Action Alternative. These flows would be insufficient to mobilize
15865 or reshape tributary deltas that can prevent bull trout access during the fall spawning season.

15866 MO2 would have slightly lower discharges from Libby Dam for the period May 15 to September
15867 30 than the No Action Alternative but would provide slightly more usable habitat for juvenile
15868 and adult redband rainbow trout than the No Action Alternative. Higher usable habitat may
15869 result in increased growth and/or survival of all life stages of redband rainbow trout.

15870 Changes in effects to burbot under MO2 include reduced flows. Median flows under MO2 as
15871 measured at Bonners Ferry between January 1 and April 30 would be lower than those under
15872 the No Action Alternative. These flows would be more likely than the No Action Alternative to
15873 provide the low and stable flows that imitate pre-dam hydrographs during burbot spawning
15874 and incubation, and thus most conducive to successful burbot recruitment.

15875 ***Hungry Horse/Flathead/Clark Fork Fish Communities***

15876 Summary of Key Effects

15877 The key effects of MO2 are largely biological responses to changes in Hungry Horse Reservoir
15878 elevations and outflows to provide additional power generation in winter. Benthic insect
15879 production important to fish would be appreciably decreased under MO2. Lower surface
15880 elevations could also increase issues with predation/exploitation risk as fish migrate into and
15881 out of tributaries to fulfill their life cycles, although bull trout would likely not be as affected
15882 because of their migration timing. Increased outflows in winter would likely result in increased
15883 entrainment of zooplankton and fish out of Hungry Horse reservoir. Winter habitat and food
15884 supply would be adversely affected in the South Fork Flathead River and mainstem Flathead
15885 River. MO2 would have negligible effects on Flathead Lake fish other than to populations that
15886 migrate into the Flathead River, and fish in the lower Flathead River and Clark Fork Rivers would
15887 encounter more stressful conditions due to flow fluctuations and increased winter flows.

15888 Habitat Effects Common to This Fish Community

15889 Winter elevations would be lower than the No Action Alternative. In wet and average years,
15890 deeper drafts in winter would result in much lower elevation upon starting refill, so with all

15891 year types considered, there would be a 67 percent annual probability of reaching elevation
15892 3,559 feet by July 31, meaning 8 more years more out of 100 that would not reach full
15893 compared to the No Action Alternative. In fall months, the elevation would be the same as the
15894 No Action Alternative, but beginning in January, MO2 reservoir elevations in wet and average
15895 years would be steeply drafted, ending the draft about seven lower than the No Action
15896 Alternative. Elevations from February through April would be 4 to 8 feet lower than the No
15897 Action Alternative. Dry year elevations would be similar through the fall and winter.

15898 Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry
15899 Horse reservoir. The zooplankton enhances food supply in the South Fork Flathead River and
15900 along the near bank of the Flathead River but decreases food supply for fish in Hungry Horse
15901 Reservoir. Outflows, and therefore zooplankton entrainment, under MO2 would be roughly
15902 double the loss as compared to the No Action Alternative in January and into February, and see
15903 spikes in entrainment when flows peak and drop in April and May. Fish entrainment would also
15904 follow a similar pattern.

15905 Outflow patterns from Hungry Horse Reservoir can also affect insect production and the habitat
15906 conditions, such as river elevation (stage), velocities, and temperatures in the river. These
15907 effects continue downstream to affect the main Flathead River in the same patterns, but
15908 somewhat attenuated by the flows in the mainstem Flathead. Temperatures in summer are
15909 regulated with a selective withdrawal structure that is operated to release water of a
15910 temperature that favors native fish. The temperature control structure would continue to
15911 operate in summer under MO2 operations. In winter, the temperature control structure is not
15912 operated, and MO2 January and February outflows would be roughly double (or more in some
15913 year types) compared to the No Action Alternative. Extreme fluctuations between high and low
15914 flows would disrupt the production of aquatic insects every time flows are increased for a time
15915 and then dropped again. Due to the removal of ramping rate restrictions there could potentially
15916 be large fluctuations in outflows throughout the year that would cause disruptions to the
15917 aquatic insects; successful recruitment of these important food sources would likely fail. These
15918 extremes in flows in winter would also substantially reduce habitat for native fish due to
15919 increased velocities making much of the habitat unsuitable.

15920 In the Flathead River down to Flathead Lake, habitat suitability is a key issue due to extremely
15921 high flows in winter and in late summer. Under MO2, January outflows in wet years would
15922 nearly double compared to the No Action Alternative. Winter flows of that magnitude could
15923 decrease the amount of suitable habitat for native fish by over 30 percent in wet years and over
15924 20 percent in average years (Muhlfeld et al. 2011). Higher-than-normal winter flows would
15925 continue to limit establishment of riparian vegetation important to fish, and spring peaks only
15926 slightly lower than the No Action Alternative would continue to occasionally provide flushing of
15927 sediments from gravels to maintain habitat. Summer temperatures would continue to be
15928 similar to the No Action Alternative because the temperature control structures would continue
15929 to operate. Higher flows in winter would increase the proportion of South Fork Flathead River
15930 flows in the mainstem Flathead River; this would increase the temperature in the mainstem
15931 Flathead River because South Fork Flathead River flows would be warmer than mainstem flows.

15932 Increased temperatures in winter could favor non-native fish over native fish, such as bull trout
15933 and westslope cutthroat trout, due to changes in productivity and metabolism. Similar to
15934 the South Fork Flathead River described in the preceding paragraph, the removal of ramping
15935 rate restrictions there could potentially be large fluctuations in outflows throughout the year
15936 that would cause disruptions to the aquatic insect production in the mainstem
15937 Flathead River as well as increase stress on fish seeking out suitable habitat.

15938 The winter water temperature warming influence from the contribution of the South Fork
15939 Flathead River would be higher in MO2 with higher winter outflows. The increased flows in the
15940 South Fork Flathead would contribute a greater proportion of reservoir water that would be
15941 warmer than river water, resulting in a larger departure from normalized temperatures than
15942 the No Action Alternative. TDG in the Flathead River would be similar to the No Action
15943 Alternative, continuing to fluctuate with spill at Hungry Horse Dam but generally would not
15944 exceed 117 percent, which is within a safe zone for fish.

15945 The influence of MO2 changes to Flathead Lake levels would be minimal. Median outflows in
15946 January would be 43 to 53 percent higher than the No Action Alternative, and February median
15947 flows would be 6 to 19 percent higher. Median April, May and June flows would be 4 to 6
15948 percent lower, and increased fluctuations would be expected compared to the No Action
15949 Alternative. In lower flow years, median summer flows would also be 5 to 6 percent lower.

15950 Bull Trout

15951 Under MO2, Hungry Horse Reservoir summer phytoplankton and zooplankton production
15952 would be minimally affected compared to the No Action Alternative. However, failing to refill
15953 more often than the No Action Alternative would result in a smaller area for aquatic insect
15954 production in those years, and steep drafts in winter would greatly reduce production of
15955 aquatic insects. Insects that had overwintered for the following spring would not be available
15956 for juvenile bull trout moving into the reservoir in the spring, and prey base for adult bull trout
15957 would be reduced. The lower reservoir elevations would result in a decrease greater than 4 to 8
15958 percent of surface area for benthic insect production all winter, especially in the bays at the
15959 upper ends of the reservoir lobes, and the steep drops would reduce the production of the
15960 large, 2-year invertebrates. Juvenile bull trout moving into the reservoir in the spring rely on the
15961 benthic insects until they transition to eating fish. The prey items that adult bull trout eat also
15962 consume the benthic insects and may be in poorer condition or less plentiful in areas.
15963 Zooplankton are an important winter food source for bull trout so increased entrainment of
15964 zooplankton would decrease their food supply in January and February. These changes in food
15965 sources could result in bull trout being in poorer condition.

15966 Under MO2, elevations in August or September would be either similar to the No Action
15967 Alternative or slightly higher (in dry years). Varial zone effects to bull trout would be similar to
15968 the No Action Alternative.

15969 Bull trout entrainment through the dam would likely increase in MO2 due to increased outflows
15970 in winter. Entrainment would be about double the No Action Alternative in January in wet and

15971 average years and February of wet years. Lower monthly outflows in spring would likely result in
15972 lower entrainment in April through June. Bull trout are likely to be near the dam during
15973 overwintering, but they would not be as concentrated there as they would be in late summer
15974 months. Late summer entrainment would be similar to the No Action Alternative. Entrainment
15975 has not been quantified but would be expected to increase under MO2 compared to the No
15976 Action Alternative.

15977 The number of individual bull trout in the South Fork Flathead River below Hungry Horse
15978 Reservoir may increase with greater entrainment, but these would be lost from their spawning
15979 populations, and would be deposited in the South Fork Flathead River during high flows that
15980 limit habitat suitability. Zooplankton available in the South Fork Flathead River may increase in
15981 winter with higher outflows, but aquatic insect production would be heavily disrupted with
15982 frequent fluctuations. As in the reservoir, food web relationships are important. The MO2
15983 operations would likely continue to allow for this transitory use by bull trout and other native
15984 fish at most times of the year, but adequate food and habitat may become limiting. Increased
15985 outflows in winter would result in much lower availability of suitable habitat for bull trout due
15986 to higher velocities.

15987 Winter flows in the mainstem Flathead River would be much higher than the No Action
15988 Alternative, further exacerbating issues with habitat suitability. Relationships described in
15989 Muhlfeld et al. (2011) between winter flows and bull trout habitat suitability indicate that bull
15990 trout habitat would be reduced by 20 percent to 30 percent in wet and average years under
15991 MO2. Nighttime habitat use by subadult bull trout would be most disrupted. At all times of the
15992 year, more extreme fluctuations would cause stress for bull trout in the mainstem Flathead
15993 River and would limit food production in this reach.

15994 The lake elevations of Flathead Lake would be similar to the No Action Alternative, as would the
15995 bull trout habitat use and life history functions in Flathead Lake. Changes described above,
15996 though, would affect bull trout from this population as they migrate into the mainstem
15997 Flathead River.

15998 MO2 would change the operations of Seli's Ksanka Qlispel Dam into the Lower Flathead River in
15999 a similar pattern as Hungry Horse operations. Outflows would be much higher in winter months
16000 and experience more variability throughout the year. The higher flows would come at a time
16001 when the area near the dam provides suitable temperatures for bull trout, so they could be
16002 subject to entrainment. Entrainment of bull trout from Flathead Lake could increase by 43 to 53
16003 percent in January and 6 to 19 percent in February. Entrained bull trout become lost from the
16004 spawning populations. Bull trout in the Lower Flathead River may experience stress as they
16005 move into freshly inundated habitats as flows increase but there would not be food available in
16006 these habitats. Decreases in flows in May and June would likely not affect bull trout in the
16007 lower river at that time of year. In summer, temperatures would make this area mostly
16008 unsuitable for bull trout under both the No Action Alternative and MO2.

16009 Other Fish

16010 Hungry Horse Reservoir would continue to favor a native fish-dominated fish community under
16011 MO2. There could be effects to native fish, but the habitat is somewhat protected from non-
16012 native fish invasion by the dam. Juvenile bull trout and adult whitefish, northern pikeminnow,
16013 sculpins, and westslope cutthroat trout feed on zooplankton, aquatic insects, and terrestrial
16014 insects, and adult bull trout prey on mountain whitefish, suckers, minnows, etc. The food web
16015 effects described above would also apply to all of these species of fish in Hungry Horse
16016 Reservoir. Zooplankton and summertime feeding of terrestrial insects would be similar to the
16017 No Action Alternative. Substantial decreases of at least 4 to 18 percent in aquatic
16018 macroinvertebrates would be expected due to reduced habitat, and dewatering events would
16019 further reduce the food supply for many of these fish.

16020 Westslope cutthroat trout and other native fish spawn in the spring (April through June) so
16021 effects on adults migrating into tributaries to spawn would differ from bull trout. Spring
16022 spawning fish migrate when reservoir levels are lower and tend to experience longer varial
16023 zones with increased predation exposure. Under MO2 operations, the modeled April and May
16024 elevations were 5 to 7 feet lower than the No Action Alternative in wet and average years, and
16025 similar in dry years. By June, the elevations would be similar to the No Action Alternative.
16026 Spring spawning fish such as westslope cutthroat trout would experience greater varial zone
16027 effects on their way upstream as adults, and they could encounter some tributary blockages,
16028 but the delta formation of these tributaries is not known. Juveniles typically outmigrate in June
16029 when the effects would be similar to the No Action Alternative.

16030 Entrainment from the reservoir would also continue at unquantified levels and could increase in
16031 the winter months with increased outflows. By winter, all species of fish can be distributed
16032 throughout the reservoir; entrainment has not been quantified but would be roughly twice as
16033 much as the No Action Alternative in winter months.

16034 Habitat suitability described for bull trout would be similar for other native fish (Muhlfield et al.
16035 2011) in the mainstem Flathead River, with higher winter flows in MO2 resulting in decreased
16036 amount of suitable habitat, and food supply becoming scarcer with decreased aquatic
16037 invertebrates.

16038 Fish in Flathead Lake would be mostly unaffected by changes in operations in MO2. The lower
16039 Flathead River and Clark Fork Rivers would provide conditions that would be more stressful to
16040 fish with rapid and more frequent fluctuations in outflows. In these scenarios, juvenile fish,
16041 especially, would be forced to seek refuge from increased flows into newly inundated habitats
16042 where no food would be available.

16043 **Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River**

16044 Summary of Key Effects

16045 Key effects under MO2 include a slight reduction in flows March through June that would
16046 reduce the threat of fish entrainment through Albeni Falls Dam relative to the No Action
16047 Alternative.

16048 Habitat Effects Common to All Fish

16049 Habitat effects from MO2 common to all fish would include the flow reduction identified above
16050 in the summary of key effects section.

16051 Bull Trout

16052 Flows would be lower in March through June under MO2 compared with the No Action
16053 Alternative. As a result, the potential for bull trout entrainment would be slightly less under this
16054 alternative.

16055 Other Fish

16056 The mean flow under MO2 would be reduced by up to 2.7 percent, depending on the time of
16057 year, when compared with the No Action Alternative. Consequently, the potential for the
16058 entrainment of other resident fish, including kokanee, westslope cutthroat trout, and northern
16059 pike, would decrease slightly under this alternative.

16060 **Region B**

16061 **Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam**

16062 Summary of Key Effects

16063 Flow, elevations, and water quality affect the quality of habitat for various resident fish species
16064 above, in, and downstream of Lake Roosevelt. The Columbia River from the U.S.-Canada border
16065 would continue to support a white sturgeon population that spawns successfully but primarily
16066 relies on fish manager intervention to survive a recruitment bottleneck; conditions for natural
16067 recruitment may be further diminished in a small proportion of years. In Lake Roosevelt,
16068 retention time is a key metric for most fish species, driving the food web that supports the fish
16069 as well as influencing how many are entrained and would be lower in winter than the No Action
16070 Alternative. Lake elevations under MO2 would increase risk of impeded tributary habitat access
16071 and egg drying out or stranding for redband rainbow trout. The portion of kokanee that spawn
16072 in tributaries would continue to have access in fall similar to the No Action Alternative, except
16073 conditions could be more difficult in dry years. Reservoir operations would continue to result in
16074 some level of eggs drying out of the burbot spawn and the portion of kokanee that spawn on
16075 lake shorelines and would increase in MO2 compared to the No Action Alternative. These
16076 effects would be a higher magnitude than MO1. MO2 would continue to support both wild and

16077 hatchery-raised kokanee, redband rainbow trout, and hatchery rainbow trout as well as non-
16078 native warmwater game species, such as walleye, smallmouth bass, and northern pike, with
16079 some effects to populations. However, decreased water retention times are expected to
16080 adversely influence reservoir productivity and increase entrainment. Northern pike would likely
16081 continue to increase and invade downstream, and the lake elevations could decrease the ability
16082 for boat suppression efforts. Rufus Woods Lake would continue to provide habitat for fish
16083 entrained from Lake Roosevelt and from limited production of shoreline spawning by some
16084 species; entrainment could increase in winter and decrease in summer months. TDG would be
16085 similar or less than the No Action Alternative.

16086 Habitat Effects Common to This Fish Community

16087 The elevation hydrograph for MO2 is very similar to MO1. Median peak outflows would follow
16088 the same pattern as the No Action Alternative with peaks in early June and another smaller
16089 peak in July. MO2 spring flows are the same as the No Action Alternative. October flows would
16090 be about eight to nine percent lower than the No Action Alternative, and December flows
16091 would be about eight to fifteen percent higher than the No Action Alternative. These peak
16092 outflows can influence the rate of entrainment from Lake Roosevelt into Rufus Woods Lake.
16093 TDG in the Grand Coulee tailwater is also a concern for fish in Rufus Woods Lake. Under MO2,
16094 TDG would be lower than the No Action Alternative.

16095 Retention time of water through the reservoir is a driving metric for the food web in Lake
16096 Roosevelt and influences the populations of several fish species. Generally speaking, under
16097 MO2 median retention time would be similar to MO1. Both would be similar to or slightly
16098 higher than the No Action Alternative in late spring, summer, and fall. Retention time under
16099 MO2 would be nine percent higher in all year types in October, 13 percent lower in December,
16100 and three percent to nine percent lower in January than the No Action Alternative. February
16101 would be six percent lower in dry years and 17 percent lower in wet years. In wet years is when
16102 retention time is lowest because more water is moving through the system, and MO2 would
16103 reduce retention times even further in winter.

16104 Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely
16105 directly on the food source provided by the zooplankton production, and higher-level predators
16106 such as bull trout prey on these fish. Zooplankton are more widespread, more plentiful, and
16107 have a larger body size when retention times are higher, and tend to be smaller bodied, swept
16108 out of the reservoir faster, and more concentrated near Grand Coulee Dam with a lower
16109 retention time. With lower retention times under MO2 in winter and spring, when retention
16110 times are already fairly low, there would be less food available to fish, and they would also tend
16111 to follow the food source and crowd down towards the dam, becoming more susceptible to
16112 entrainment. These are the same mechanisms of effects as MO1 but at higher magnitudes for a
16113 moderate effect. Decreased retention time in September in MO2 would flush out zooplankton
16114 that provide key winter food sources.

16115 Bull Trout

16116 Bull trout are temperature sensitive and would continue to use this reach for foraging,
16117 migration, and winter habitat until temperatures reach stressful levels that would be the same
16118 as the No Action Alternative. Bull trout in Lake Roosevelt could continue to move to cooler
16119 locations in the reservoir, and these refuges would remain similar to the No Action Alternative.
16120 High flow years would continue to influence bull trout distribution through flushing more of
16121 them from the river near the U.S.-Canada border down into Lake Roosevelt. Peak flows at the
16122 U.S.-Canada border were modeled showing flows similar to the No Action Alternative. Similar to
16123 MO1, increased outflows in December could potentially increase entrainment of bull trout, but
16124 this is negligible because of the scarcity of bull trout in Lake Roosevelt.

16125 Bull trout prey base would continue to fluctuate, as the fish they eat are sensitive to changes in
16126 productivity and location of zooplankton in Lake Roosevelt that is influenced by the retention
16127 time of water in the reservoir, which would be adversely affected by lower retention times in
16128 winter under MO2. Bull trout are also sensitive to contaminants that are found in this region
16129 and would continue to bioaccumulate contaminants as a top predator. Similar to MO1,
16130 fluctuation events that mobilize mercury would be the same as the No Action Alternative.

16131 Other Fish

16132 In the Columbia River reach from the U.S.-Canada border to Lake Roosevelt, white sturgeon are
16133 typically able to spawn as evidenced by capture of young of the year larvae (Howell and
16134 McLellan 2018), but rarely experience successful recruitment from larvae to juvenile sturgeon,
16135 and only in extremely high water years. Successful recruitment appears to be dependent on a
16136 combination of flows exceeding 200 kcfs and water temperatures of about 14°C for 3 to 4
16137 weeks in late June/early July (Howell and McLellan 2011 and Howell and McLellan 2014). In
16138 MO2, flow over 200 kcfs in June and July would be slightly decreased. The timing of these flows
16139 coinciding with lower reservoir levels can also increase recruitment ability with the longer
16140 riverine habitat provided by a lower reservoir. MO2 reservoir levels would be very similar to the
16141 No Action Alternative and the time window for white sturgeon recruitment would be the same
16142 as the No Action Alternative. Other factors that would continue to influence sturgeon include
16143 predation by fish that are favored by reservoir conditions if larvae are flushed into the Lake
16144 Roosevelt. Spring flows would be the same as the No Action Alternative. The uptake of
16145 contaminants such as copper closer to the U.S.-Canada border being flushed downstream into
16146 the reservoir by high flows would also be the same as the No Action Alternative. Under MO2,
16147 recruitment of white sturgeon would continue to be a rare event supplemented by hatchery
16148 propagation, as larval sturgeon are captured and raised in hatcheries until they are past the
16149 time window where recruitment has been shown to fail at a high rate. Once these juveniles are
16150 released back into the reservoir they continue to grow and survive well. The reservoir would
16151 continue to provide good conditions for growth and survival of these fish.

16152 Wild production of native fish such as burbot, kokanee and redband rainbow trout would
16153 continue to provide valuable resources in Lake Roosevelt. As described in the common habitat
16154 effects, these fish are the most sensitive to the effects of changing retention times. Under the

16155 No Action Alternative an estimated average of over 400,000 fish annually would be entrained,
16156 with 30 to 50 percent of them being kokanee, primarily of wild origin and rainbow trout the
16157 second most entrained species. Under MO2 operations, increased entrainment would be
16158 expected in winter months as the outflows increase over the No Action Alternative, and
16159 retention times would be 12 percent to 13 percent lower in December and 3 percent to 9
16160 percent lower in January. Previous entrainment studies (LeCaire 2000) indicated winter being a
16161 period relatively low entrainment. The prolonged drawdown period is expected to increase
16162 entrainment in winter months under MO2. In wet years entrainment would also be higher in
16163 March to May (2 percent to 6 percent lower retention time) which could increase entrainment
16164 at a disproportionately high rate. Decreased food sources due to flushing of zooplankton in fall
16165 could limit kokanee growth, and juvenile burbot rely on this food as well.

16166 For tributary spawning species such as redband rainbow trout and a portion of the wild
16167 production of kokanee, tributary access at the right time of year is important. Reservoir
16168 drawdown in the spring creates barren tributary reaches through the varial zone, which directly
16169 and indirectly impedes migration to and from tributaries and the reservoir. The operational
16170 metric of reaching a lake elevation of 1,283 feet by the end of September would be met under
16171 MO2 in wet and average years and would protect the access for the portion of kokanee that
16172 spawn in tributaries. In dry years, the reservoir would only reach elevation of 1,279 feet by
16173 September and may cause some access issues. Redband rainbow trout need access to
16174 tributaries in the spring. Under MO2, similar to MO1, reservoir elevations would be lower than
16175 the No Action Alternative levels in the critical spawning migration time of April-May in wet and
16176 dry years (equaling about 40 percent of years). This would be most critical in wet years (20
16177 percent of years) when the median elevation would be 1,241 feet on April 1, which is lower
16178 than the No Action Alternative. Migratory impacts, although not well documented, could be
16179 severe for Redband rainbow trout given the timing and extent of drawdowns in MO2. Redband
16180 rainbow trout spawn in Sanpoil, Blue Creek, Alder, Hall Creek, Nez Perce Creek, Onion Creek,
16181 Big Sheep Creek, and Deep Creek. These tributaries higher in the basin are more susceptible to
16182 elevation changes, because a smaller change in lake elevation would result in a larger area of
16183 exposure than tributaries closer to the dam. Additionally, increased exposure during migrations
16184 to these tributaries would increase the varial zone effect where migrating fish are more
16185 exposed to predation and angling due to lack of cover.

16186 Species such as kokanee and burbot that spawn on shorelines in Lake Roosevelt are susceptible
16187 to eggs drying out if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on
16188 shoreline gravels September 15 to October 15 and eggs incubate through February. Burbot
16189 tend to spawn successfully in depths provided by the No Action Alternative in the Columbia
16190 River and in Lake Roosevelt on shorelines near the Colville River in winter with eggs incubating
16191 through the end of March (Bonar et al. 2000). MO2, like MO1, would begin dropping 2 months
16192 sooner than the No Action Alternative and would likely strand or dewater burbot and kokanee
16193 eggs. A higher proportion of eggs at all elevations would be affected.

16194 The portion of kokanee that spawn in the shallower 6 feet of elevations could have eggs dry out
16195 when these drops occur. Any eggs near the fall surface elevation would be at higher risk. Fry

16196 sometimes also stay in the gravels and could become stranded as well. Burbot spawn later in
16197 the winter so would be less affected because the lake level would have already dropped seven
16198 feet lower than the No Action Alternative when eggs would be deposited. However, this same
16199 mechanism would also decrease habitat available compared to the No Action Alternative. The
16200 wet years would have steeper and deeper reservoir draft than the No Action Alternative and
16201 would result in increased stranding of burbot eggs. The magnitude of this effect is even higher
16202 than MO1 because MO2 would drop steeper in February than MO1, both of which would be
16203 considerably more drop than the No Action Alternative.

16204 Kokanee are very sensitive to water temperature, and during summer are found at depths
16205 below 120 m to find suitably cool water. Under the No Action Alternative, Lake Roosevelt is
16206 very weakly stratified but does have suitably cool water at this depth along with suitable levels
16207 of DO. Lake whitefish and mountain whitefish also likely use this cool water in the summer.

16208 Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish,
16209 crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all
16210 tolerate a wide range of environmental conditions and would continue to contribute to the
16211 fishery community under the No Action Alternative, and continue to adversely impact native
16212 species via predation. The invasion downstream by northern pike is of concern, and the Lake
16213 Roosevelt Co-Managers are actively suppressing pike populations using gillnets set by boats as
16214 soon as they can get on the water in the spring until the boat ramp becomes unusable at
16215 elevation of 1,235 feet. Under the No Action Alternative, this occurs on April 15 in wet years,
16216 and would not occur at all in dry and average years. Like MO1, under MO2 in wet years this
16217 would occur up to 6 days and preclude the ability for the pike suppression efforts for that
16218 period. For estimation purposes, one crew typically removes about 100 pike per week and they
16219 would operate three crews (Colville Tribe unpublished data), so the lost opportunity of up to 6
16220 days under MO2 could result in an estimated 300 pike not removed. Additionally, outflows and
16221 retention time would continue to influence the entrainment and downstream invasion of non-
16222 native gamefish below Chief Joseph Dam where ESA-listed anadromous salmonids would be
16223 susceptible to predation by them. During the time when pike juveniles would be most
16224 susceptible to entrainment, (May to August), retention time under MO2 would be similar or
16225 slightly higher so entrainment risk for juvenile pike could be similar to the No Action Alternative
16226 or slightly lower. However, as pike distribution increases downstream in the reservoir, adults
16227 and juveniles both would become more susceptible to entrainment and the increased winter
16228 outflow would increase entrainment.

16229 Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt
16230 would experience similar effects as their native counterparts except for spawning and early
16231 rearing effects. In addition, the net pen locations are situated where the water quality can be
16232 affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG,
16233 and their eventual recruitment to the fishery can be affected by retention time coupled with
16234 reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May.
16235 Under the MO2, the water quality at these locations would be similar to the No Action
16236 Alternative in most locations, although a decrease in DO was shown in the Spokane arm, which

16237 could reduce the suitability of that location. The retention time in May would be either similar
16238 or slightly higher so entrainment risk would be the same as the No Action Alternative or slightly
16239 less. The operators strive to release these fish to coincide with the initiation of reservoir refill
16240 when outflows are reduced, which under MO2 would be the same as the No Action Alternative,
16241 so these fish would continue to be release when water quality conditions would be suitable.

16242 The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake
16243 Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter
16244 drawdown periods. The earlier start to winter drawdown and increased outflows for power
16245 generation in MO2 may increase entrainment and boost populations in Rufus Woods Lake.
16246 Decreased outflows in August and September likely would decrease entrainment. This lake has
16247 more riverine characteristics with steep gradients and narrow canyon walls, making it more like
16248 a river than a reservoir, with short retention time and low productivity. High flows during late
16249 spring and early summer would continue to flush eggs and larvae from protected rearing areas
16250 similar to the No Action Alternative, but slightly lower magnitude. Median peak outflows occur
16251 in early June and would be about 3 percent lower than the No Action Alternative. TDG in the
16252 Grand Coulee tailwater is a concern for fish in Rufus Woods Lake; modeling showed TDG would
16253 be lower than the No Action Alternative.

16254 ***Chief Joseph to McNary Dam***

16255 Summary of Key Effects

16256 Key effects from alternative MO2 would not be different from the No Action Alternative.

16257 Habitat Effects Common to All Fish

16258 Habitat effects from alternative MO2 common to all fish would be similar to those found in the
16259 No Action Alternative.

16260 Bull Trout

16261 Important effects to bull trout under alternative MO2 would not be different from the No
16262 Action Alternative.

16263 Other Fish

16264 Effects of alternative MO2 to the current fish community in this reach of the Columbia River
16265 would be similar to the No Action Alternative.

16266 **Region C**

16267 ***Snake River Basin***

16268 Summary of Key Effects

16269 Effects from MO2 that differ from the No Action Alternative would include decreases in dam
16270 passage survival for fish passing downstream, lower water levels at Dworshak Reservoir that
16271 would reduce connectivity with tributary streams, reduced levels of TDG from lower spill
16272 volumes, and increased risk of kokanee entrainment at Dworshak Reservoir from increased
16273 winter flows.

16274 Habitat Effects Common to All Fish

16275 Common habitat effects of MO2 are similar to those identified for the No Action Alternative
16276 with the exception of the changes discussed in the section above.

16277 Bull Trout

16278 Effects to bull trout from MO2 would include a slight increase in mortality from downstream
16279 passage of the lower Snake River Dams. Reductions in spill and associated TDG that would reduce
16280 the risk of GBT to bull trout in May and June, and large reductions in pool elevations at Dworshak
16281 Dam from May through July that would decrease connectivity of reservoir and tributary habitats.
16282 Under MO2 more flow would be put through turbines relative to the No Action Alternative.
16283 Because turbine survival is generally lower than spillway or bypass survival there would be a
16284 minor increase in mortality of bull trout routed through these turbines.

16285 Because relatively more flow would be routed through the powerhouse at the Snake River
16286 dams under MO2, spill would be reduced, as would the risk of GBT for all species of fish.

16287 Under MO2, winter releases from Dworshak Reservoir would be increased considerably.
16288 Reservoir pool elevation could be lower in June, which could increase migratory risks for bull
16289 trout in a much larger varial zone.

16290 Other Fish

16291 Effects of MO2 to white sturgeon would be similar to those for bull trout. Downstream passage
16292 at dams in the lower Snake River would be associated with increased mortality relative to the
16293 No Action Alternative while risks of GBT would decrease as spill and TDG are reduced.

16294 Effects of MO2 to other resident fish species would also be similar to those for bull trout.
16295 Kokanee, particularly, in Dworshak Reservoir tend to congregate towards the dam during
16296 winter, and median winter outflows would be three times higher than the No Action Alternative
16297 in January and 40 percent higher in February in median years. This magnitude of outflows
16298 would likely result in major increased kokanee entrainment out of Dworshak. In the lower
16299 Snake River, downstream passage of fish through CRS projects would be associated with
16300 increased mortality relative to the No Action Alternative while risks of GBT would decrease as
16301 spill and TDG are reduced.

16302 **Region D**

16303 ***Mainstem Columbia River from McNary Dam to the Estuary***

16304 Summary of Key Effects

16305 Bull trout would continue to use the Columbia River in limited numbers and seek thermal
16306 refugia available at the mouths of tributaries. White sturgeon would continue to successfully
16307 reproduce in years with adequate flow and temperature conditions.

16308 Habitat Effects Common to this Fish Community

16309 Outflows from McNary Reservoir influence some of the fish relationships described in this
16310 section. Peak spring flows affect habitat maintenance for some species. Modeled median
16311 outflows for MO2 indicate that outflows would be within 2 percent of the No Action Alternative
16312 (no discernable change).

16313 Other flow parameters referred to in this section refer to outflows of McNary Dam, which are
16314 indicative of flows on downstream through the other Projects.

16315 Bull Trout

16316 Bull trout are known to use the mainstem Columbia River to move between tributaries and
16317 have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et
16318 al. 2016). Water temperature is the most important habitat factor for bull trout in the
16319 mainstem Columbia. Under MO2, bull trout would continue to use the mainstem Columbia for
16320 migration between tributaries, as well as tributary mouths for passage and thermal refugia.

16321 Passage through turbines can cause injury or mortality. MO2 includes turbine replacement,
16322 with IFP turbines, which would improve survival (Deng et al. 2019). At John Day, turbine
16323 replacement would provide safer passage for any bull trout that move through the dam.

16324 Bull trout would continue to be subject to bird predation.

16325 Other Fish

16326 Under MO2, white sturgeon spawning and recruitment would be similar to the No Action
16327 Alternative during high and average flow years. In low flow years, it is likely that there is very
16328 little spawning and recruitment anyway, but overall conditions would be similar to the No
16329 Action Alternative.

16330 Model results indicate suitable spawning temperatures would be similar to the No Action
16331 Alternative. In years of low flow conditions, water temperatures could increase beyond the
16332 suitable range by early June, resulting in little or no recruitment.

16333 White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse
16334 substrates (Parsley et al. 1993). Minor changes in outflow under MO2 would not be large
16335 enough to cause discernable velocity changes that would affect sturgeon spawning habitat.

16336 MO2 does not include any measures to improve passage at the dams for sturgeon.

16337 White sturgeon larvae are adversely affected by TDG. Studies have shown high rates of altered
16338 buoyancy at 118 percent TDG, and 50 percent mortality at 131 percent TDG (Counihan et al.
16339 1998). Adults are more able to compensate for increased TDG by moving to lower depths, but
16340 larvae in shallow water would be more affected. Under MO2, TDG rates would be less than the No
16341 Action Alternative, because spill rates would be limited to 110 percent TDG.

16342 MO2 would be similar to the No Action Alternative in terms of pool fluctuation (potential
16343 juvenile stranding), predation from pinnipeds and warmwater game fish, and reservoir
16344 maturation.

16345 Under MO2, no changes to resident fish communities would be expected. As shown above,
16346 outflow rates below McNary Dam would be very similar to the No Action Alternative. Water
16347 quality and food availability would also be similar to the No Action Alternative.

16348 Conditions that promote lower water temperatures and higher spring flows tend to lower the
16349 survival rates of warmwater game fish, potentially lowering populations of predators on salmon
16350 and steelhead. MO2 would be expected to continue supporting warmwater game fish at levels
16351 similar to current conditions.

16352 **MACROINVERTEBRATES**

16353 Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under MO2. For more
16354 detailed information on the effects of MO2 on aquatic invertebrates and implications on food
16355 web interactions see the Habitat Effects section of these respective fish community analyses in
16356 the Resident Fish section under the applicable region.

16357 **Region A**

16358 At Hungry Horse reservoir, the varial zone that provides benthic insect production would be
16359 similar to the No Action Alternative in the summer, except that the reservoir would miss filling
16360 more often due to lower winter elevations. Winter elevations would be about four to eight feet
16361 lower than the No Action Alternative and be drafted faster. There would be less habitat and
16362 aquatic insects in this zone would become dewatered faster than under the No Action
16363 Alternative, which would especially impact the insects with two-year life cycles. The elevation
16364 at the end of September would be similar to the No Action Alternative, with dry years actually
16365 slightly higher than the No Action Alternative due to implementing a sliding scale. With similar
16366 summer elevations, the euphotic zone for summer zooplankton production would be similar.
16367 However, increased numbers of zooplankton would leave out of the reservoir and into the
16368 South Fork Flathead River with higher outflows in January and February (often more than

16369 double those of the No Action Alternative) and in April and May. These outflows would increase
16370 zooplankton levels and wetted area for macroinvertebrate production in the South Fork
16371 Flathead River, but water level fluctuations in the South Fork Flathead River in January to
16372 February, April to May, May to June, and June to July would all cause disruptions to the aquatic
16373 insects. These fluctuations would not allow enough continuous time at steady river elevations
16374 for invertebrates to fulfil their life cycle. Additionally, higher flows would flush more
16375 macroinvertebrates out of the immediate downstream area with higher velocities than the No
16376 Action Alternative. This flow pattern would continue to the mainstem Flathead River and
16377 increase wetted area there but also dewater macroinvertebrates with frequent fluctuations,
16378 reduce amount of low velocity habitat, and flush macroinvertebrates out of the river
16379 downstream into Flathead Lake. Increased winter flows would continue downstream through
16380 the Clark Fork River and could slightly increase aquatic invertebrate habitat in winter.

16381 The MO2 operations of the Albeni Falls Project would result in similar lake elevations as the No
16382 Action Alternative, but increased inflows from upstream in January would be passed through so
16383 inflows to the Pend Oreille River would about 22 percent higher in January. Macroinvertebrate
16384 communities could occupy those habitats but would become dewatered as flows recede again
16385 in February.

16386 In the Kootenai basin, Lake Koocanusa would be held above elevation 2450 for a similar
16387 duration as the No Action Alternative; overall productivity of zooplankton and
16388 macroinvertebrates in the system would be similar. Likewise, MO2 operations would result in a
16389 median minimum pool elevation within a foot of the No Action Alternative and typically slightly
16390 lower, exposing similar or slightly less varial zone production to dewatering.

16391 **Region B**

16392 The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic
16393 insects such as stonefly, caddisfly, and mayfly larvae. The river elevation in this reach is
16394 influenced by Lake Roosevelt operations and inflows so is somewhat variable, which would
16395 constrain benthic production to some degree.

16396 MO2 operations would be very similar to MO1. This would change river elevations at the U.S.-
16397 Canada border in the months of December and January, with much steeper drops than the No
16398 Action Alternative. MO2 levels would follow the same pattern as the No Action Alternative
16399 through April with rising elevations until July, then dropping steeply until September, when
16400 they rise again. The No Action Alternative and MO2 levels would then level off about
16401 November, but in December MO2 levels would drop quickly, whereas No Action Alternative
16402 levels would rise slightly and hold steady for another month and then drop at a lower rate. This
16403 would result in decreased habitat and more benthic production becoming dewatered than the
16404 No Action Alternative from December through about March 1. This change in elevation drops of
16405 4 feet represents the vertical feet; actual habitat dewatered would depend on the slope of the
16406 riverbanks at this elevation. As the river flows downstream closer to Lake Roosevelt, the
16407 pattern is the same but the additional drop from MO2 would result in about six feet lower
16408 elevation at river mile 720.

16409 In Lake Roosevelt, the production, distribution and persistence of zooplankton is highly variable
16410 and sensitive to retention time of water in the reservoir, which is a function of inflows, reservoir
16411 volume, and outflows. The longer residence times allow for increased abundance and larger-
16412 bodied zooplankton to be more widely distributed throughout the reservoir. Lower retention
16413 times result in fewer and smaller-bodied zooplankton that get concentrated near the dam,
16414 where they would be subject to high rates of entrainment. Retention time under MO2 would be
16415 very similar to MO1; meaning median retention time would be similar to the No Action
16416 Alternative in late spring, summer, and fall. Retention time under MO2 would be lower in
16417 December through January, but slightly higher in May in most years. In wet years is when
16418 retention time is lowest because more water is moving through the system, and MO2 would
16419 reduce retention times even further in these years by up to 10 percent in February and by 3
16420 percent to 10 percent in the entire period of December through May. With lower retention
16421 times under MO2 in winter and spring, when retention times are already low, there would be
16422 less productivity and increased entrainment of zooplankton. The larger, longer-lived species
16423 would be disproportionately affected. The elevations in Lake Roosevelt would follow the same
16424 pattern as in the river sections described above, with MO2 elevations dropping about 7 feet
16425 December 1st rather than staying steady as in the No Action Alternative. This would result in
16426 desiccation of more aquatic macroinvertebrates and overall decreased habitat in shallow areas
16427 of the reservoir.

16428 Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with
16429 steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short
16430 retention time and low productivity. Here the macroinvertebrate community consists of
16431 production of aquatic insects similar to upstream of Lake Roosevelt, as well as the zooplankton
16432 entrained out of Lake Roosevelt. Regarding aquatic insect production and desiccation, river
16433 stage at RM 594 in Rufus Woods Lake would follow the same pattern and magnitude changes
16434 as the No Action Alternative from April through December. At that time, however, the river
16435 stage would rapidly increase about a foot for a short time period and then drop back down to
16436 similar to the No Action Alternative. In the month of March, the stage would be slightly lower
16437 by about a half of a foot for less than a month. Aquatic macroinvertebrate habitat would be
16438 relatively similar to the No Action Alternative most of the year. The temporary increase in
16439 December could result in colonization of a small amount of habitat that would then become
16440 dewatered and desiccate these invertebrates, as could the minor, temporary decrease in
16441 March.

16442 **Region C**

16443 MO2 operations would result in a steep, 34-foot drop in elevation in January through March,
16444 while the elevation under the No Action Alternative would stay fairly level at this time. This
16445 steep drop would severely decrease benthic habitat and further desiccate any established
16446 production. Summer elevations would be similar to the No Action Alternative, with steep drops
16447 from July through September. Already low levels of benthic production in Dworshak reservoir
16448 would be even further reduced. More extensive variation in water surface elevation, near-shore
16449 wave action that causes erosion, and the lack of aquatic plants along the shoreline would

16450 further limit production. The summer euphotic zone for zooplankton production would be
16451 similar to the No Action Alternative.

16452 In the Clearwater River below Dworshak Reservoir, flows would be about five times higher than
16453 the No Action Alternative outflows in January, and then variably lower and higher than the No
16454 Action Alternative in February and March. This extreme increase in winter flows would greatly
16455 reduce the suitability of benthic habitat in the Clearwater River in winter. Summer flows would
16456 be similar to the No Action Alternative, which are also unsuitably high for natural production of
16457 macroinvertebrates in a river system.

16458 Conditions in the lower Snake River would be similar to the No Action Alternative. The
16459 macroinvertebrate community of the lower Snake reservoirs and river would continue similar
16460 to the No Action Alternative. Siberian prawns and opossum shrimp may continue to increase in
16461 the reservoir environments. The reservoirs would continue to provide habitat for clams,
16462 mussels, etc., as in the No Action Alternative, and crayfish would find ample suitable habitat in
16463 the rock and riprap of reservoirs. Soft substrates of the reservoirs would continue to be
16464 dominated by low species diversity, mostly worms. Harder substrates would provide habitat for
16465 a relatively poor diversity of aquatic insect larvae.

16466 **Region D**

16467 MO2 would result in only minor changes to flows or temperatures that could affect
16468 macroinvertebrate communities in the lower Columbia River. Very little benthic
16469 macroinvertebrate information is available for the lower Columbia River. Lake habitats in the
16470 impounded reaches would continue to support a low diversity of worms, benthic insects, and
16471 mollusks. The other run of river dams would continue to be operated at stable elevations that
16472 would continue production of these aquatic macroinvertebrates.

16473 **SUMMARY OF EFFECTS**

16474 **Anadromous Fish**

16475 MO2 includes structural measures to improve survival of juvenile salmon and steelhead.
16476 However, operational measures such as lower spill and lower spring flows for flood risk
16477 management and hydropower would increase travel time and the number of powerhouse
16478 encounters for juvenile outmigrants. MO2's spill to near 110 percent TDG decreases the
16479 proportion of spill at each of the lower Columbia and lower Snake projects. This reduced spill
16480 has the net effect of routing more juvenile salmon and steelhead towards powerhouse routes
16481 and less salmon and steelhead through spill routes. Structural measures such as powerhouse
16482 surface collectors did not result in sizeable increases in juvenile survival or improvements in
16483 adult returns.

16484 TDG exposure levels under MO2 are expected to be similar or slightly reduced compared to the
16485 No Action Alternative. Modeled species such as juvenile upper Columbia River spring-run
16486 Chinook and upper Columbia River steelhead, are expected to see decreases in survival,

16487 increases in travel time, increases in powerhouse passage events, and decreased adult return
16488 rates.

16489 The expected effects of MO2 on anadromous species varied depending on the species, location,
16490 and by the outputs from the two distinct models (CSS and LCM) used in this analysis. For upper
16491 Columbia River Chinook salmon and steelhead, the LCM predicted one to four percent relative
16492 reductions in-river survival as well as a one percent relative reduction in the SAR estimate for
16493 upper Columbia River spring Chinook.

16494 For Snake River spring Chinook and steelhead, the CSS model generally predicted adverse
16495 effects, a 30 percent relative reduction in SARs for spring Chinook, while the LCM generally
16496 predicted negligible to minor beneficial effects relative to anadromous species that were
16497 modeled in the No Action Alternative. The minor beneficial effects result from increases in
16498 transportation rates.

16499 MO2 also includes structural modifications at the dams to benefit passage of adult salmon,
16500 steelhead, and Pacific lamprey. While structural modifications may provide some benefit to
16501 lamprey passage, the overall shift to more powerhouse flow and passage makes this alternative
16502 less effective at meeting the objective to improve conditions for lamprey than the other action
16503 alternatives. Greater numbers of lamprey would likely pass near fish bypass screens and would
16504 be at a higher risk of injury or impingement compared to the No Action Alternative.

16505 **Resident Fish**

16506 In some regions, MO2 would generally have some key effects similar to the No Action
16507 Alternative, with minor to major adverse effects in localized areas. In Region A, discharges from
16508 Libby Dam would continue to have detrimental effects to fish species downstream, with lower
16509 food production and less habitat. Benthic insect production would be decreased in Region A
16510 reservoirs under MO2 due to changes in reservoir operations to provide additional power
16511 generation in winter. Reductions in flows would reduce the threat of fish entrainment at certain
16512 projects in summer but increases in winter outflows at Hungry Horse would cause a major
16513 decrease in bull trout habitat in the Flathead River, as well as increase entrainment of fish and
16514 winter food sources. In Region B, changes in elevations and outflows of Lake Roosevelt (Grand
16515 Coulee Dam) would result in moderate adverse effects to kokanee, burbot, and redband
16516 rainbow trout due to reduced retention times, more severe adfluvial effects limiting access to
16517 tributaries, and increased egg desiccation. In Region C, Dworshak Reservoir outflow increases in
16518 winter would likely result in major adverse effects due to increases in kokanee entrainment. In
16519 the lower Snake River, more flow would be put through the turbines relative to the No Action
16520 Alternative; species such as bull trout migrating downstream in the Snake River would see a
16521 minor increase in mortality compared to spillway or bypass passage. In Region D, effects in the
16522 Lower Columbia River would be minor adverse to negligible.

16523 **Macroinvertebrates**

16524 Changes in operations at projects such as Hungry Horse and Lake Roosevelt would result in
16525 winter elevations lower than the No Action Alternative that are drafted faster, resulting in less
16526 habitat and aquatic insects. In areas such as the Clearwater River below Dworshak Reservoir,
16527 extreme increases in winter flows and variability would greatly reduce the suitability of benthic
16528 habitat. Conditions in the lower Snake and Columbia Rivers are expected to be similar to those
16529 in the No Action Alternative. Overall, effects are expected to be moderate.

16530 **3.5.3.6 Multiple Objective Alternative 3**

16531 **ANADROMOUS FISH**

16532 **Salmon and Steelhead**

16533 Several different ESU/DPS units of salmon and steelhead share a similar life cycle and
16534 experience similar effects from the MOs, but also have ESU-DPS specific traits that specifically
16535 drive effects differently from one another. Common effects analyses across all salmon and
16536 steelhead are discussed first, and then those ESU/DPS specific effects are displayed.

16537 ***Effects Common Across Salmon and Steelhead***

16538 Summary of Key Effects

16539 MO3 would involve breaching the lower Snake River embankments, which would end juvenile
16540 fish transportation at the collector projects, and would have effects on both juvenile
16541 outmigration and adult upstream migration.

16542 Upon the breaching of the LSR dams, Bonneville would no longer have an obligation to fund US
16543 Fish and Wildlife Service for the operations and maintenance of the LSRCP facilities.

16544 Bonneville's funding authority is directly tied to the operation of the LSR dams. The co-lead
16545 agencies also recognize that there would be transitional needs that would be addressed in the
16546 additional mitigation measures for MO3 discussed in Chapter 5. Additionally, the Bonneville
16547 F&W Program funding for offsite mitigation projects in the Snake River Basin, implemented by
16548 local, state, tribal, and federal entities, would be reviewed and potentially adjusted. Any
16549 changes of this nature would be implemented over time as the effectiveness of dam breaching
16550 is observed and would be done in consultation with fish and wildlife managers, regulatory
16551 agencies, and the Northwest Power and Conservation Council. Consistent with this, offsite
16552 mitigation projects for the other CRS dams would be reviewed and could be adjusted as
16553 operations change over time. Proposed project modifications would be coordinated with
16554 project sponsors and regional stakeholders to determine appropriate funding levels.

16555 Juvenile Fish Migration/Survival

16556 With the breaching of lower Snake River dams, hatchery mitigation would change, as noted
16557 above. Currently, hatchery fish account for 80 to 90 percent of all juvenile Snake River fish
16558 passing CRS projects. COMPASS and CSS models do not account for this potential major

16559 reduction in juvenile fish production and as noted throughout this chapter, unless otherwise
16560 specified, quantitative results from COMPASS, CSS, and the LCM are based on a combination of
16561 hatchery and natural origin fish. This applies for both juvenile and adult results. Consequently,
16562 qualitative analyses are added to these modeling results.

16563 MO3's spill to 120 percent TDG at the lower Columbia projects increases the proportion of spill
16564 at each of the lower Columbia projects. This increased spill at the lower Columbia projects has
16565 the net effect of routing more juvenile salmon and steelhead towards spill routes and less
16566 salmon and steelhead would pass through powerhouse routes. For juvenile salmon and
16567 steelhead, fish modeling was used when available to estimate the effects of these spill changes
16568 and dam breach on fish.

16569 Flow patterns in the Lower Columbia River also changed in MO3 relative to the No Action
16570 Alternative and these included decreases in monthly average flows of 1 to 3 percent from
16571 March to August. Similar to the spill changes, fish modeling was used when available to
16572 estimate the effects of these flow changes on juvenile fish. These flow changes were caused by
16573 one or a combination of the following operational measures:

- 16574 • Sliding Scale at Libby and Hungry Horse
- 16575 • Modified Draft at Libby
- 16576 • December Libby Target Elevation
- 16577 • Update System FRM Calculation
- 16578 • Planned Draft Rate at Grand Coulee
- 16579 • Grand Coulee Maintenance Operations
- 16580 • Lake Roosevelt Additional Water Supply
- 16581 • Hungry Horse Additional Water Supply
- 16582 • Chief Joseph Dam Project Additional Water Supply

16583 Increasing the operating range by 6 inches John Day Dam relative to the No Action Alternative
16584 would slightly increase juvenile fish travel times and exposure to predators (NMFS 2019).
16585 Similarly, holding contingency reserves within juvenile fish passage spill is likely to have little
16586 effect on juvenile migration. These measures were both included in the 80-year modeling
16587 datasets.

16588 Several measures in MO3 are not readily incorporated into modeling for effects analysis, or are
16589 modeled but may be difficult to separate from other factors, and so effects of these measures
16590 are discussed qualitatively.

16591 As discussed in the analysis for MO1 and MO2, the replacement of existing weirs (top spill or
16592 removable) with adjustable spillway weirs would likely allow greater flexibility to address
16593 tailrace eddies. This would also allow for longer spillway weir operation under lower flow
16594 conditions towards the end of the juvenile spring/summer-run Chinook outmigration.

16595 The removal of fish screens at some dams would reduce in-river survival in the COMPASS model
16596 to some degree but would not have an effect on in-river survival in the CSS model. Removing
16597 fish screens would shift fish that would have otherwise entered the juvenile bypasses into other
16598 routes, likely turbine routes. This measure was included in the modeling datasets.

16599 Operating turbines within and above 1 percent efficiency may or may not affect juvenile Snake
16600 River spring/summer-run Chinook direct survival based on studies finding that peak passage
16601 survival does not coincide with observed turbine peak operating efficiency (Mathur et al. 2000;
16602 Skalski et al. 2002; Deng et al. 2007). A meta-analysis also found no association between relative
16603 turbine efficiency at a site and smolt passage survival (Skalski et al. 2002). However, Ferguson et
16604 al. (2006) reported spring-run Chinook delayed mortality resulting from operation of McNary Dam
16605 turbines outside the 1 percent range; so it is possible that operating outside 1 percent turbine
16606 efficiencies at some dams may decrease Snake River spring/summer-run Chinook survival.

16607 The measures intended to improve conditions for lamprey in MO3 are anticipated to have a
16608 negligible effect on salmon and steelhead survival.

16609 No juvenile fish would be transported. Overall, MO3 is somewhat similar to the No Action
16610 Alternative from a TDG perspective but shows a small reduction in overall TDG exposure.

16611 UW/CBR TDG modeling, separate from COMPASS and CSS in-river survival estimates, estimated
16612 juvenile fish median reach average exposure to TDG indices would change depending on dams
16613 passed, from a decrease of about 5 percent for Snake River fish to an increase of up to 1
16614 percent for upper Columbia fish relative to the No Action Alternative.

16615 There would be anticipated decrease in fish injury from dam passages under MO3 due to
16616 breach of the four lower Snake Dams, installation of improved fish passage turbines at John Day
16617 Dam, and higher spill in the lower Columbia, relative to the No Action Alternative, and
16618 anticipated concomitant decrease in juvenile predation exposure due to these factors.

16619 Turbidity is anticipated to change under MO3 during the breach phase and years immediately
16620 following the breach especially (see Section 3.4, *Water Quality*). The increase in turbidity during
16621 these periods is anticipated to reduce predation. Over time, turbidity is likely to reach an
16622 equilibrium close to the No Action Alternative and it is unclear how overall predation would
16623 change relative to the No Action Alternative. However, the predators that would remain are
16624 more likely to be native predators adapted to riverine system and shift away from predators
16625 that are well adapted to reservoir habitats. Decreased travel time through the lower Snake
16626 River will also reduce juvenile salmon and steelhead predation by birds and fish. The reduced
16627 predation risk due to faster travel times and increased turbidity may be offset by some
16628 unknown amount due to reduced predator swamping effects stemming from the loss of
16629 hatchery fish.

16630 Adult Fish Migration/Survival

16631 Overall, the Bonneville Dam ladder structural measure may reduce delay for adult fish passing
16632 under crowded conditions; however adult fallback rates may also increase under MO3 due to
16633 higher spill levels at the lower Columbia projects, which could increase adult fish delay (Boggs
16634 et al. 2004; Keefer et al. 2005). It is important to note that regional managers use in-season
16635 adaptive management to identify and remedy any excessive fallback.

16636 Increasing the reservoir operating range at John Day Dam would have little effect on flow, and
16637 thus is not expected to affect adult migration timing or survival rates. Similarly, holding
16638 contingency reserves within juvenile fish passage spill would be likely to have little effect, if any,
16639 on adult migration.

16640 Several changes affecting migration through the breached section would occur, including:
16641 Maximum summer water temperature would increase slightly; water temperature variability
16642 would increase; and water temperatures would not stay cool as long into the spring and would
16643 cool earlier in the fall with the removal of the thermal inertia of the lower Snake Dam
16644 reservoirs. See additional information in Section 3.4, *Water Quality*, and Appendix D.

16645 The breached areas are not expected to delay adult migration because they would be designed
16646 to pass fish at flows up to 170,000 cfs, equivalent to a 5-year high-flow event. Flows less than 5
16647 feet per second (ft/s) are not considered to impede adult upstream migration and would
16648 require no additional resting structures. All Lower Snake breaches would provide velocities
16649 between 2 to 3 ft/s and flow depths around eight feet for total river flows of 15,000 cfs. As river
16650 flows increase, so do velocities and flow depths. Typical overbank velocities associated with
16651 170,000 cfs range between 3 ft/s to 8 ft/s with flow depths between 22 and 28 feet. Velocities
16652 in the breach area at flows greater than 170,000 cfs could be in ranges that may impede
16653 movement even with structures. The high flow periods occur in the spring when spring-run
16654 Chinook salmon, sockeye salmon, and some steelhead migrate upstream through the lower
16655 Snake River.

16656 In any breached areas where velocities are predicted to be above 5 ft/s at flows less than
16657 170,000 cfs, channel enhancement features would be installed to assist fish in migrating
16658 upstream in steps. Where overbank velocities exceed 5 ft/s, channel enhancement features,
16659 such as precast 6-foot boulders, would be placed to provide energy dissipation along the bank
16660 to provide resting locations. The spacing of these features ranges from about 200 feet at 5 ft/s
16661 to 10 feet for 12 ft/s. The location and extent of channel enhancement features would be
16662 detailed in future hydraulic modeling efforts.

16663 ***Upper Columbia River Salmon and Steelhead***

16664 Upstream of McNary Dam, upper Columbia salmon and steelhead migrate past as many as five
16665 PUD owned dams and reservoirs, which also impact the survival and passage of these species.
16666 The federal agencies do not dictate generation or spill levels at the PUD projects so metrics
16667 such as powerhouse encounter rate are not directly affected but are influenced by river flow

16668 levels coming through the upper Basin. The timing and volume of flow levels affected by CRS
16669 operational decisions are reflected in model analysis. COMPASS and LCM estimates of
16670 powerhouse encounter rate and SARs include passage effects from a combination of federal
16671 and PUD dam passage (Rock Island Dam to Bonneville Dam). CSS model results are not available
16672 for upper Columbia stocks.

16673 Upper Columbia Spring-Run Chinook Salmon

16674 *Summary of Key Effects*

16675 COMPASS modeling estimates that MO3 is expected to result in a 1 percent increase in upper
16676 Columbia River Chinook average juvenile survival, an 8 percent decrease in average juvenile
16677 travel time, and a 12 percent decrease the number of powerhouse passage events.

16678 *Juvenile Fish Migration/Survival*

16679 CSS cohort modeling for upper Columbia spring-run Chinook was not available for this analysis,
16680 but the COMPASS model estimates based on a combination of hatchery and wild fish that MO3
16681 would have the following effects on upper Columbia spring Chinook, compared to the No
16682 Action Alternative, described below in Table 3-85:

16683 **Table 3-85. Multiple Objective Alternative 3 Juvenile Model Metrics for Upper Columbia River**
16684 **Spring-Run Chinook Salmon**

Metric (Model)	NAA	MO3	Change from NAA	% Change
Juvenile Survival (COMPASS) McNary to Bonneville	69.5%	71.0%	+1.5%	+2%
Juvenile Travel Time (COMPASS) McNary to Bonneville	6.1 days	5.4 days	-0.7 days	-11%
% Transported	No upper Columbia River spring-run Chinook transported			
Powerhouse Passages (COMPASS) Rock Island to Bonneville	3.29	2.9	-0.39	-12%
TDG Average Exposure (TDG Tool)	115.9% TDG	116.7% TDG	+0.8% TDG	0.05%

16685 The COMPASS modeling results support initial qualitative expectations that the predicted MO3
16686 survival rates from McNary Dam to Bonneville Dam would increase slightly and travel times
16687 would be reduced slightly.

16688 For upper Columbia spring-run Chinook salmon, UW/CBR modeling estimated that the McNary
16689 to Bonneville Dam reach-average TDG exposure index would change less than 1 percent in MO3
16690 relative to the No Action Alternative.

16691 *Adult Fish Migration/Survival*

16692 NMFS LCM results were provided for the only extant upper Columbia spring-run Chinook MPG:
16693 the North Cascades MPG, using the Wenatchee River population. CSS LCMs for upper Columbia
16694 species are not available for this analysis. Based on LCM model predictions, a negligible increase

16695 in SARs for upper Columbia Chinook and a variable increase in abundance is estimated based on
16696 latent mortality assumptions. See Table 3-86 for details:

16697 **Table 3-86. Model Metrics Related to Adult Survival and Abundance of Upper Columbia River**
16698 **Spring-Run Chinook Salmon under Multiple Objective Alternative 3**

Metric (Model)	NAA	MO3	Change from NAA	% Change
SARs – Rock Island to Bonneville (NWFSC LCM)	0.94%	0.95%	+0.01%	+1%
NWFSC LCM abundance range with decreased latent mortality ¹	498	519 (0%)	+21 (0%)	+4% (0%)
		636 (10%)	+138 (10%)	+28% (10%)
		882 (25%)	+384 (25%)	+77% (25%)
		1228 (50%)	+730 (50%)	+147% (50%)

16699 ¹ NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARS or abundance output. For
16700 discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent are shown.
16701 The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent
16702 scenarios of what SARs, or abundance hypothetically could be under the increased ocean survival if changes in the
16703 alternative were to decrease latent mortality by that much.

16704 Current life-cycle models do not incorporate interactions between populations (straying,
16705 source-sink dynamics, etc.) or between MPGs, though these dynamics are generally known to
16706 occur. That said, they provide useful frameworks for assessing how populations are likely to
16707 respond to factors that are correlated with survival or abundance.

16708 For upper Columbia spring-run Chinook, the (NMFS LCM estimates that MO3 would have the
16709 following effects compared to operations under the No Action Alternative:

- 16710 • No change in smolt to adult (SAR) return rate from, Rock Island to Bonneville (this estimate
16711 includes passage past three Public Utility District dams) but large increase in SAR if
16712 productivity also increases by 50 to 100 percent (i.e., additional reduction in latent mortality
16713 that could be a result of reduced powerhouse encounters in the lower Columbia);
- 16714 • Upper Columbia spring-run Chinook adult abundance would increase over time with overall
16715 small increases in median abundance, but potentially substantial increases across the
16716 modeled population if productivity also increases by 50 to 100 percent (i.e., additional
16717 reduction in latent mortality).

16718 Upper Columbia River Steelhead

16719 *Summary of Key Effects*

16720 COMPASS modeling estimates that MO3 is expected to result in a less than 1 percent decrease
16721 in average juvenile survival for upper Columbia steelhead, a less than 1 percent increase in
16722 average juvenile travel time, (roughly 2 hours) and a 7 percent decrease in the number of
16723 powerhouse passage events from McNary to Bonneville Dam.

16724 *Juvenile Fish Migration/Survival*

16725 CSS modeling for upper Columbia steelhead was not available for this analysis, but the
16726 COMPASS model estimates that MO3 would have the following effects compared to the No
16727 Action Alternative, described below in Table 3-87.

16728 **Table 3-87. Multiple Objective Alternative 3 Juvenile Model Metrics for Upper Columbia River**
16729 **Steelhead**

Metric (Model)	NAA	MO3	Change from NAA	% Change
Juvenile Survival (COMPASS) McNary to Bonneville	65.8%	65.6%	-0.2%	0%
Juvenile Travel Time (COMPASS) McNary to Bonneville	6.6 days	6.7 days	+0.1 days	0%
% Transported (COMPASS)	No transport of upper Columbia steelhead			
Powerhouse Passages (COMPASS) Rock Island to Bonneville	2.72	2.52	-0.20	-7%
TDG Average Exposure (TDG Tool)	116% TDG	117.0% TDG	+1% TDG	0%

16730 For upper Columbia River juvenile steelhead, UW/CBR modeling estimated that the McNary to
16731 Bonneville Dam reach-average TDG exposure index would increase by about one percent
16732 relative to the No Action Alternative.

16733 *Adult Fish Migration/Survival*

16734 No LCM results were provided for the upper Columbia River steelhead DPS, which is composed
16735 of a single MPG: the North Cascades MPG. NMFS LCM for steelhead are still in development
16736 and not available for this analysis and CSS LCM of MOs was not provided for upper Columbia
16737 species.

16738 Upper Columbia River Coho Salmon

16739 See upper Columbia River spring-run Chinook salmon analysis as a surrogate for juvenile upper
16740 Columbia coho salmon and upper Columbia fall Chinook salmon analysis as a qualitative
16741 surrogate for adult upper Columbia River coho salmon.

16742 *Summary of Key Effects*

16743 The primary challenges for upper Columbia coho salmon are the conditions they encounter
16744 during upstream and downstream migrations. Overall, minor increase in survival is anticipated
16745 for juvenile upper Columbia coho between McNary and Bonneville dams, based on modeling
16746 completed for the surrogate species of upper Columbian River spring-run Chinook juveniles
16747 (Table 3-88). CRS operational changes are not likely to affect survival rates for upper Columbia
16748 adult coho migrating upriver.

16749 *Juvenile Fish Migration/Survival*

16750 See Upper Columbia River spring run Chinook salmon for estimated, surrogate measures of
16751 juvenile survival under MO3 compared to the No Action Alternative. Modeling of surrogate
16752 species indicates that juvenile coho survival would have minor increases and that under MO3
16753 could also slightly reduce upper Columbia coho juveniles' susceptibility to predation by other
16754 fish and birds of prey based on modeled changes in the number of turbine passages, travel
16755 time, and installation of improved fish passage turbines at John Day Dam.

16756 For an overview of juvenile and adult predation generally under MO3, see the Effects Common
16757 Across Salmon and Steelhead section, under Section 3.5.3.6.

16758 *Adult Fish Migration/Survival*

16759 See the Effects Common across Salmon and Steelhead section, under Section 3.5.3.6, for an
16760 overview of change in adult migration/survival for salmon and steelhead under MO3 relative to
16761 the No Action Alternative.

16762 Under MO3, CRS operational changes are not likely to affect survival rates for upper Columbia
16763 adult coho migrating upriver. For more information, see surrogate effects analysis of MO3 for
16764 *Upper Columbia Fall Chinook*.

16765 Upper Columbia River Sockeye Salmon

16766 Refer to the upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia
16767 River sockeye salmon.

16768 *Summary of Key Effects*

16769 The most notable effects for Columbia River sockeye from MO3 are the minor benefits that
16770 would occur downstream from the confluence with the Snake River. Breaching of the lower
16771 Snake River dams would increase turbidity during breaching and in high water events for some
16772 unknown period after the breach. Increased turbidity reduces predation on juvenile salmon
16773 from sight feeding predators. In addition, increased abundance of Snake River salmon
16774 populations, following dam breach may contribute to Columbia River population survival as
16775 larger numbers of outmigrating juveniles may swamp predators. However, the magnitude of
16776 these changes is uncertain.

16777 *Juvenile Migration/Survival*

16778 This alternative (MO3) is expected to have small decrease to migration time for juvenile
16779 sockeye as measured from Rock Island Dam to Bonneville Dam, and would have a small
16780 increase in juvenile survival during their migration period of April 15 to June 15. Modeled river
16781 flows during the driest 25 percent of years would be slightly lower, but not a substantial
16782 difference from the No Action Alternative.

16783 A minor increase in survival is expected for the upper Columbia River sockeye due to effects of
16784 breaching the lower Snake River Dams. These effects would come from the increase in turbidity
16785 levels from the Snake River, which may help the survival of smolts as they would be less visible
16786 to predators.

16787 Under MO3 there would be displacement of some predators below the confluence of the Snake
16788 and Columbia Rivers following breaching until conditions stabilize and populations return to
16789 affected areas. Overall, there would be a negligible decrease in risk of sockeye predation by
16790 larger fish at the time of breaching, followed by gradual increases in risk of exposure to these
16791 predators as the habitat and water quality stabilize.

16792 An increase in colonial waterbird nesting habitat is expected in the area of the lower Ice Harbor
16793 pool. Only those islands that would not be inundated in spring flows are suitable habitat. This
16794 may increase the local bird population in McNary pool and would affect the rate of predation
16795 on Columbia River sockeye.

16796 Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia
16797 River sockeye salmon, for additional information in modeled juvenile fish migration and survival
16798 metrics.

16799 *Adult Migration/Survival*

16800 The summer water temperatures in the river during the upstream migration would not change.
16801 Likewise, TDG and its effects in the form of GBT would have no appreciable difference in MO3
16802 for either adults (or juveniles).

16803 Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia
16804 River sockeye salmon, for additional information in modeled adult fish migration and survival
16805 metrics.

16806 Upper Columbia River Summer/Fall-Run Chinook Salmon

16807 *Summary of Key Effects*

16808 Overall, no changes are anticipated for juvenile upper Columbia summer/fall-run Chinook.
16809 There may be slightly less adult migration delay due to slightly fewer days when water
16810 temperatures in the McNary tailrace exceed 20°C, but slightly greater adult migration delay due
16811 to slightly higher incidence of adult ladder temperature differentials above 2°C.

16812 *Juvenile Fish Migration/Survival*

16813 No change is anticipated in McNary and John Day Reservoir plankton communities or shoreline
16814 habitats under MO3, relative to the No Action Alternative (see Section 3.4, Water Quality, and
16815 the Resident Fish subsection of Section 3.5.2.5 for additional information). Likewise, juvenile
16816 rearing habitat below Bonneville Dam is not expected to change relative to the No Action

16817 Alternative. Overall, no changes are anticipated for juvenile upper Columbia summer/fall-run
16818 Chinook.

16819 *Adult Fish Migration/Survival*

16820 Specific to Okanogan upper Columbia summer/fall-run Chinook, there is no change in number
16821 of days the mainstem would be 20°C or higher at the confluence of the Okanogan River, relative
16822 to the No Action Alternative. This means that there would be no change anticipated in the
16823 ability of the Okanogan fish to hold in the mainstem until temperatures in the Okanogan River
16824 are cool enough that adults can move up from the mainstem without having to migrate through
16825 water temperatures typically considered lethal for salmon and steelhead (Ashbrook et al.
16826 2009).

16827 The frequency of meeting the Vernita Bar Agreement to protect the prolific fall-run Chinook
16828 spawning in and around the Hanford Reach of the Columbia River in Washington is not
16829 expected to change under any MOs relative to the No Action Alternative. Other operational
16830 changes under MOs are likewise not anticipated to affect upper Columbia summer/fall-run
16831 Chinook spawning from the tailrace of Chief Joseph Dam to Bonneville Dam in terms of changes
16832 in flows, water temperatures, or TDG generated under the MOs.

16833 ***Middle Columbia River Salmon and Steelhead***

16834 Middle Columbia River Spring-Run Chinook Salmon

16835 See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River
16836 Spring-Run Chinook Salmon.

16837 *Summary of Key Effects*

16838 CRS operational changes under MO3 will result in increased survival, faster travel times, and
16839 decreased powerhouse passage events on juvenile middle Columbia River Chinook salmon.
16840 These effects would lead to negligible to minor benefits to Middle Columbia River Spring
16841 Chinook.

16842 *Juvenile Fish Migration/Survival*

16843 See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River
16844 Spring-Run Chinook Salmon.

16845 *Adult Fish Migration/Survival*

16846 See upper Columbia River spring-run Chinook salmon analysis as a surrogate for adult migration
16847 and survival of middle Columbia River spring-run Chinook salmon.

16848 Middle Columbia River Steelhead

16849 Refer to Upper Columbia River steelhead analysis as a surrogate for Middle Columbia River
16850 steelhead.

16851 *Summary of Key Effects*

16852 Juvenile and adult middle Columbia River Steelhead would be exposed to moderate increases in
16853 TDG. Other effects to juvenile fish would be similar to those experienced by Upper Columbia
16854 steelhead. Adult middle Columbia River steelhead would experience minor increases in fallback
16855 rates, but kelts would also experience minor increases in survival.

16856 *Juvenile Fish Migration/Survival*

16857 Populations of middle Columbia River steelhead distributed between the Deschutes and Walla
16858 Walla Rivers pass two to four dams in the lower Columbia on their downstream outmigration to
16859 the ocean. COMPASS modeling for juvenile upper Columbia River steelhead was used as a
16860 surrogate for middle Columbia River steelhead. Under MO3, juvenile survival, travel time and
16861 powerhouse encounters would both have a small decrease from the No Action Alternative.
16862 However, these fish would experience a moderate increase in elevated TDG. Refer to upper
16863 Columbia River steelhead analysis as a surrogate for middle Columbia River steelhead for
16864 additional information.

16865 *Adult Fish Migration/Survival*

16866 Under MO3, higher spill levels at the lower Columbia projects during spring outmigration would
16867 result in minor increases in fallback rates. However, there would also be minor increases in
16868 survival of kelts as they migrate downstream because fewer adults would pass through the
16869 powerhouse (Normandeau et al. 2014). There would also be moderate increases in TDG under
16870 MO3 compared to the No Action Alternative. Refer to upper Columbia River steelhead analysis
16871 as a surrogate for middle Columbia River steelhead for additional information.

16872 ***Snake River Salmon and Steelhead***

16873 Snake River Spring/Summer-Run Chinook Salmon

16874 *Summary of Key Effects*

16875 COMPASS and CSS modeling results indicate that survival rates would increase and travel times
16876 would decrease (fish would migrate downstream faster). However, the potential reduction of
16877 hatchery fish noted in the common effects analysis may reduce numbers of juvenile Snake River
16878 Chinook salmon by as much as 85 percent. This reduction would potentially result in lower
16879 survival rates of wild Chinook as they navigate through the predators inhabiting the migratory
16880 corridor. The model estimates for both CSS and LCM presented in this section are based on a
16881 combination of hatchery and wild fish. The CSS model was able to produce similar estimates
16882 using wild fish only, but because those estimates still assume that hatchery fish are present and

16883 migrating along with the natural origin fish, they do not represent an estimate of a wild fish
16884 only migration such as may occur if hatchery production was reduced or eliminated post-dam
16885 breach. The CSS wild fish estimates are presented in memo form (See appendix E) for
16886 reference.

16887 *Juvenile Fish Migration/Survival*

16888 For Snake River spring/summer-run Chinook salmon, the COMPASS and CSS models estimate
16889 that MO3 would have the following effects compared to operations under the No Action
16890 Alternative, described below in Table 3-88. As noted above, the model estimates in Table 3-89
16891 were developed with a combination of hatchery and natural origin fish data. COMPASS results
16892 reflect data obtained from the Salmon River wild and hatchery combined estimates.

16893 **Table 3-88. Multiple Objective Alternative 3 Juvenile Model Metrics for Snake River**
16894 **Spring/Summer-Run Chinook Salmon**

Metric (Model)	NAA	MO3	Change from NAA	% Change
Juvenile Survival (COMPASS)	50.4%	59.9	+9.6%	+19%
Juvenile Survival (CSS)	57.6%	68.2%	+14.9%	+25.9%
Juvenile Travel Time (COMPASS)	17.7 days	12.2 days	-5.5 days	-31%
Juvenile Travel Time (CSS)	15.8 days	11.3 days	-4.5 days	-28%
% Transported (COMPASS)	38.5%	0%	-38.5%	-100%
% Transported (CSS)	19.2%	0%	-19.2%	-100%
Transport: In-River Benefit Ratio (CSS)	0.86	No transport	N/A	N/A
Powerhouse Passages (COMPASS)	2.25	0.74	-1.51	-74%
Powerhouse Passages (CSS)	2.15	0.62	-1.53	-71%
TDG Average Exposure (TDG Tool)	115.1% TDG	109.3% TDG	-5.1% TDG	-4%

16895 The COMPASS and CSS modeling results indicate that survival rates would increase by as much
16896 as 25 percent and travel times would decrease by nearly 30 percent (resulting in fish moving
16897 faster through the current hydrosystem) relative to the No Action Alternative. However,
16898 reductions in hatchery fish could reduce numbers of juvenile Snake River Chinook salmon by as
16899 much as 85 percent. This reduction in the number of hatchery fish would likely result in a
16900 reduction of these predicted survival rates of wild Chinook because of increased predation
16901 rates. The dam breach measures in MO3 would eliminate the transportation program for
16902 juvenile Snake River spring/summer-run Chinook.

16903 For Snake River spring/summer-run Chinook salmon, UW/CBR TDG modeling estimated that the
16904 Lower Granite to Bonneville reach-average TDG exposure index would decrease by about 5
16905 percent in MO3.

16906 *Adult Fish Migration/Survival*

16907 **Table 3-89. Multiple Objective Alternative 3 Adult Model Metrics for Snake River**
16908 **Spring/Summer-Run Chinook Salmon**

Metric (Model)	NAA	MO3	Change from NAA	% Change
LGR-BON SARs (NWFSC LCM) ^{1/}	0.88% (0%)	1.0% (0%)	+0.12% (0%)	+14% (0%)
		1.1% (10%)	+0.12% (10%)	+25% (10%)
		1.2% (25%)	+0.36% (25%)	+42% (25%)
		1.5% (50%)	+0.61% (50%)	+70% (50%)
LGR-LGR SARs (CSS)	2.0%	5.4%	+3.4%	+170%
Abundance of Middle Fork Salmon and South Fork Salmon representative populations (NWFSC LCM)	1527	1659 (0%)	+132 (0%)	+9% (0%)
		1951 (10%)	+424 (10%)	+28% (10%)
		2345 (25%)	+818 (25%)	+54% (25%)
		3160 (50%)	+1633 (50%)	+107% (50%)
Abundance (CSS) ^{2/}	6114	14055	+7941	+103%

16909 1/ NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARs or abundance output. For
16910 discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent are shown.
16911 The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent
16912 scenarios of what SARs, or abundance hypothetically could be under the increased ocean survival if changes in the
16913 alternative were to decrease latent mortality by that much.

16914 2/ CSS provided results for six populations in the Grande Ronde/Imnaha Major Population Group. The absolute
16915 values represent those populations only; the percent change is considered indicative of the Snake River ESU for the
16916 purpose of comparing between MOs.

16917 For Snake River spring/summer-run Chinook salmon, the NMFS LCMs and CSS LCM indicate that
16918 MO3 may result in a wide range of predicted increases to SAR rates. CSS predicts SARs from
16919 Lower Granite to Lower Granite would increase by about 170 percent relative to the No Action
16920 Alternative. The NMFS Life Cycle Model predicts relative increases in Lower Granite to
16921 Bonneville SARs that range from 14 percent to 70 percent depending on the magnitude of
16922 potential reductions in latent mortality.

16923 The NWFSC LCM results generally indicate high variability in potential fish response to dam
16924 breach depending on the breach scenario input dataset used for calibration. The CSS LCM
16925 results generally indicate that MO3 adult abundance over time would show substantial
16926 increases from the No Action Alternative.

16927 Several structural measures in MO3 are anticipated to benefit adult Snake River
16928 spring/summer-run Chinook passage upstream and these include modifying the upper ladder
16929 serpentine sections at Bonneville Dam (reducing migration delay). Overall, as with the other
16930 MOs, neither CSS nor the LCM indicates that powerhouse surface passage structures in MO3
16931 would have a substantial effect on adult abundance over a 30-year period.

16932 Fallback rates of Snake River spring/summer-run Chinook at the lower Columbia dams may
16933 increase under MO3 since fallback for this ESU has been associated with higher flow and higher
16934 spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). In those studies, fish that fell
16935 back were less likely to reach their spawning areas compared to fish that never fell back. For
16936 example, of the 11 percent of Snake River spring- summer Chinook that fell back at Bonneville

16937 dam nearly 14 percent failed to reascend (Boggs et al. 2004). Thus, the MO3 higher spill
16938 operation may result in a small increase in the fallback of Snake River spring/summer-run
16939 Chinook salmon adults as they migrate upstream. It is important to note that regional managers
16940 use in-season adaptive management to identify and remedy any excessive fallback. So while the
16941 average survival for Snake River spring/summer-run Chinook salmon adults may decrease
16942 slightly from the recent averages of about 89 percent in the Bonneville to McNary Dam reach
16943 under the No Action Alternative, increased fallback is not anticipated to have a large effect
16944 under this alternative.

16945 Spill cessation starting August 1 at the lower Columbia River dams would likely have negligible
16946 effects on summer migrating adults (fallback-related effects) and no effects on spring migrating
16947 adults. While fallback rates may be lower, individuals that fell back would experience greater
16948 risk of falling back through turbines and juvenile bypass systems compared to spillways once
16949 the spill cessation trigger is met at individual lower Snake projects. Adult migration through the
16950 breached lower Snake segment is discussed in the following section.

16951 Increasing the reservoir operating range at John Day Dam would have little effect on flow, and
16952 thus is not expected to affect adult migration timing or survival. Similarly, holding contingency
16953 reserves within juvenile fish passage spill would have negligible effects on adult migration.

16954 Collectively, the water management measures and water supply measures in MO3 would have
16955 negligible effects to Snake River spring/summer-run Chinook.

16956 Several changes would occur affecting migration through the breached section, including the
16957 following: Maximum summer water temperature would increase slightly; water temperature
16958 variability would increase; and water temperatures would not stay cool as long into the spring
16959 and would cool earlier in the fall with the removal of the thermal inertia of the lower Snake
16960 dam reservoirs. See additional information in Section 3.4, Water Quality, and Appendix D.

16961 The breached areas are not expected to delay adult migration because they would be designed
16962 to pass fish at flows up to 170,000 cfs, equivalent to a five-year high flow event. Flows less than
16963 this rate are not considered to impede adult upstream migration and would require no
16964 additional resting structures. All Lower Snake breach locations provide velocities between 2 to
16965 3 feet per second and flow depths around eight feet for total river flows of 15,000 cfs. As total
16966 river flows increase, so do velocities and flow depths. While velocities in the breach area at
16967 flows greater than 170,000 cfs could be in ranges that may impede movement even with
16968 structures, upstream migration does not occur during these high flows. The high flow periods
16969 occur in the spring when spring-run Chinook salmon, sockeye salmon, and some steelhead
16970 migrate upstream through the lower Snake River.

16971 In any breached areas where velocities are predicted to be above 5 ft/s at flows less than
16972 170,000 cfs, channel enhancement features would be installed to assist fish in migrating
16973 upstream in steps. Where overbank velocities exceed 5 ft/s, channel enhancement features
16974 such as precast 6-foot boulders would be placed to provide energy dissipation along the bank
16975 to provide resting locations. The spacing of these features ranges from about 200 feet at 5 ft/s

16976 to 10 feet for 12 ft/s. The location and extent of channel enhancement features would be
16977 detailed in future hydraulic modeling efforts.

16978 Snake River Steelhead

16979 *Summary of Key Effects*

16980 Quantitative model estimates show that MO3 may result in higher juvenile Snake River
16981 steelhead survival, reduced travel times and decreased powerhouse passage events. Because
16982 the lower Snake projects would be breached, juvenile fish transportation would be eliminated.
16983 Steelhead kelts and overwintering steelhead moving downstream in the breached section of
16984 the Snake should also experience higher survival rates and faster travel times. The model
16985 estimates for both CSS and COMPASS presented in this section are based on a combination of
16986 hatchery and wild fish. The CSS model also produced similar estimates using wild fish only; but
16987 because those estimates still assume that hatchery fish are present and migrating concurrently
16988 with the natural origin fish, those estimates are not representative of a wild fish only migration.
16989 This does not capture what would occur if Lower Snake River Compensation hatchery
16990 production was reduced or eliminated post-dam breach. The wild fish specific estimates from
16991 CSS are contained in Appendix E for reference.

16992 *Juvenile Fish Migration/Survival*

16993 For Snake River steelhead, the COMPASS and CSS models estimate that MO3 would increase
16994 juvenile survival and reduce travel time, elevated TDG, and powerhouse encounters (Table 3-90).

16995 **Table 3-90. Multiple Objective Alternative 3 Juvenile model metrics for Snake River Steelhead**

Metric (Model)	NAA	MO3	Change from NAA	% Change
Juvenile Survival (COMPASS)	42.7%	52.7%	+10%	+23%
Juvenile Survival (CSS)	57.1%	83.1%	+26.0%	+46%
Juvenile Travel Time (COMPASS)	16.4 days	9.0 days	-7.4 days	-45%
Juvenile Travel Time (CSS)	16.2 days	11.0 days	-5.2 days	-32%
% Transported (COMPASS)	39.7%	0	-39.7	-100%
% Transported (CSS)	Unknown	0	N/A	N/A
Transport: In-River Benefit Ratio (CSS)	1.41	No Transport	N/A	N/A
Powerhouse Passages (COMPASS)	1.73	0.42	-1.31	-76%
Powerhouse Passages (CSS)	1.96	0.46	-1.5	-77%
TDG Average Exposure (TDG Tool)	115.1% TDG	109.4% TDG	-5.5% TDG	-5%

16996 The COMPASS and CSS modeling results indicate that survival rates would increase between 23
16997 and 46 percent relative to the No Action Alternative and that travel times would decrease
16998 between 32 and 45 percent relative to the No Action Alternative. However, potential
16999 reductions of hatchery fish may also reduce numbers of juvenile Snake River steelhead as
17000 discussed above for Chinook salmon. This potential reduction in the number of hatchery fish
17001 would likely result in a reduction of these predicted survival rates of steelhead because of

17002 increased predation rates since the two stocks currently migrate downstream together. The
17003 dam breach measures in MO3 would eliminate juvenile Snake River steelhead transportation.

17004 For Snake River steelhead, the UW/CBR TDG modeling estimated that the Lower Granite to
17005 Bonneville Dam reach-average TDG exposure index would decrease by about 5 percent.

17006 *Adult Fish Migration/Survival*

17007 For Snake River steelhead, the CSS cohort model estimates that MO3 would produce a
17008 substantial increase (178 percent) in SAR relative to the No Action Alternative. The CSS model
17009 estimated an absolute SAR of 5.0 percent. There are no LCM model estimates available for this
17010 DPS (Table 3-91).

17011 **Table 3-91. Multiple Objective Alternative 3 Adult Model Metrics for Snake River Steelhead**

Metric (Model)	NAA	MO3	Change from NAA	% Change
SARs LGR-LGR (CSS)	1.8	5.0	+3.2	+178%

17012 Higher spill levels at the lower Columbia projects during April should result in higher survival
17013 rates for adult Snake River steelhead falling back through dams and kelts migrating
17014 downstream. Fewer adults use powerhouse passage routes when a spill route is available and
17015 overall downstream passage increased when surface passage was available (Normandeau et al.
17016 2014; Ham et al. 2012).

17017 Steelhead kelts and overwintering steelhead moving downstream in the breached section of the
17018 Snake River should experience both higher survival rates and faster travel speeds. It is
17019 challenging to estimate additional mortality rates due to dam passage for kelts compared to a
17020 free-flowing river environment because mortality is naturally high following spawning. Keefer et
17021 al. (2017) used radio telemetry to estimate survival and travel speeds of adult steelhead
17022 upstream to spawning tributaries in the Snake River, and the return migration to the ocean.
17023 Approximately 85 percent of steelhead died after reaching their natal tributary but before
17024 initiating the kelt migration through the hydrosystem. Outmigration survival was a minimum of
17025 31 to 39 percent past the four lower Snake dams and a minimum of 13 to 20 percent past all
17026 eight dams. English et al. (2006) compared kelt migration speeds through the middle Columbia
17027 and four undammed rivers in British Columbia and found travel speed for kelts was substantially
17028 faster in the free-flowing rivers however, water velocity and gradient were not closely correlated
17029 with fish travel time.

17030 Snake River Coho Salmon

17031 See Snake River spring/summer-run Chinook salmon as a surrogate for juvenile Snake River
17032 coho salmon and Snake River fall-run Chinook as a surrogate for adult Snake River coho salmon.

17033 *Summary of Key Effects*

17034 Overall, MO3 would reduce juvenile coho salmon travel time, powerhouse encounters, and
17035 TDG while increasing juvenile survival.

17036 *Juvenile Fish Migration/Survival*

17037 See Snake River spring/summer-run Chinook salmon as a surrogate for juvenile Snake River
17038 coho salmon.

17039 *Adult Fish Migration/Survival*

17040 Long-term effects of MO3 on Snake River adult coho would include a lower risk of delay and
17041 fallback because four of the dams would be breached. Temperatures would be reduced during
17042 adult migration with the total number of days where temperatures are over 20°C at Ice Harbor
17043 Dam. Susceptibility to disease would also diminish with lower migration temperatures. All of
17044 these effects would improve long-term survival and spawning success of Snake River coho
17045 salmon.

17046 Short-term effects under this alternative include elevated suspended sediments and depleted
17047 DO levels during breaching that if not mitigated could lead to major losses of adult coho
17048 salmon.

17049 Snake River Sockeye Salmon

17050 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile
17051 Snake River sockeye salmon.

17052 *Summary of Key Effects*

17053 Key long-term effects of MO3 would improve downstream and upstream migration survival
17054 through the lower Snake River due to breaching the four dams. Benefits would accrue through
17055 faster downstream travel time, fewer powerhouse encounters, lower predation, and reduced
17056 TDG effects.

17057 Significant short-term effects could occur due to the large amount of suspended sediment and
17058 reduced DO due to breaching the dams. There would be the potential for large-scale mortality
17059 for any fish in the river during this construction work.

17060 *Juvenile Migration/Survival*

17061 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake
17062 River sockeye salmon.

17063 *Adult Migration/Survival*

17064 The percent of days over 18°C between June 21 and July 31 would be 87.3 percent, which is
17065 three additional days over 18°C compared to the No Action Alternative. This means Snake River
17066 sockeye might have slightly greater thermal stress than under the No Action Alternative.
17067 However, breaching of the four lower Snake River dams is expected to reduce delays in
17068 upstream migration and decrease the time fish are exposed to the slightly warmer water
17069 temperatures. Additionally, sockeye would not have the transportation effects that can
17070 increase straying and fallback and prolong their exposure to thermal stress.

17071 MO3 would eliminate temperature differences between the river and the fish ladders at the
17072 dam locations. In addition, breaching the four lower Snake River dams would result in moderate
17073 decreases in elevated TDG in the Snake River compared to the No Action Alternative.

17074 Another water quality parameter important during upstream migration is the amount of
17075 suspended sediment in the water. The typical sediment load is around 2 mg/L of total
17076 suspended solids. Excavation for the dam breach measure of MO3 would cause a large
17077 sediment plume each year and potentially during runoff of the following 2 to 7 years. The
17078 estimates are nearly 25,000 mg/L during excavation for each breach and 30 mg/L after breach.
17079 Approximately 27 days would have suspended sediment over 5,000 mg/L. In the conceptual
17080 design proposed for analysis, the timing of dam breaching would occur at the tail end of the
17081 adult sockeye migration through the lower Snake River. Therefore, only the latest few fish in
17082 the run for two consecutive years of construction would experience the high turbidity levels in
17083 the river. The estimated severity of the sediment pulse indicates mortality between 20 and 40
17084 percent of fish downstream of these dams. However, the vast majority of Snake River sockeye
17085 would have passed upstream from the dams by the time these levels are reached; therefore,
17086 MO3 would have minor increases in mortality of these fish compared to the No Action
17087 Alternative.

17088 Under MO3, breaching the four Lower Snake River dams would cause DO levels to drop to
17089 approximately 2 mg/L throughout the Little Goose and Lower Monumental pool areas in the
17090 year of construction. Sockeye salmon need around 5 mg/L of DO for survival. Sockeye salmon
17091 become stressed at lower levels and can suffocate with prolonged lack of oxygen. There may be
17092 some loss of late migrating sockeye in these two pools during the peak of sediment release,
17093 which is the primary cause of the drop in DO in the water; however, almost all of the adult
17094 sockeye would have already passed upstream prior to construction.

17095 Under MO3, the lack of juvenile transportation would reduce the fallback and straying. Straying
17096 may still occur but would be at the natural levels for this population. This would improve
17097 homing compared to the No Action Alternative and would reduce risk of incidental catch in the
17098 middle Columbia River fisheries. Reductions in delay, fallback, and straying are likely under
17099 MO3.

17100 Snake River Fall-Run Chinook Salmon

17101 *Summary of Key Effects*

17102 Key long-term effects of MO3 for fall-run Chinook would be the major increase in available
17103 spawning habitat. Other major improvements would include the downstream migration
17104 survival through the lower Snake River due to breaching the four dams. Benefits would accrue
17105 through faster downstream travel time, fewer powerhouse encounters, substantially less
17106 predation, and reduced TDG.

17107 Major short-term effects would occur due to the large amount of suspended sediment during
17108 dam breaching. There is the potential for large-scale mortality for any fish in the river during
17109 this construction work.

17110 *Larval Development/Juvenile rearing*

17111 Breaching the four lower Snake River Dams is estimated to increase the available spawning
17112 habitat for fall-run Chinook from 226 acres to 3,521 acres, an increase of 15 times the area
17113 available today (Corps 2002). The mean depth of water would be reduced, but fall-run Chinook
17114 use a wide range of depths for spawning and would be expected to take advantage of the new
17115 area available due to dam breaching. MO3 would lead to large increases in spawning habitat
17116 and improved conditions for spawning.

17117 Under MO3, juvenile fall-run Chinook may move downstream to use McNary and John Day
17118 reservoirs for rearing. One of the long-term effects is that the portion of the fish that
17119 overwinter in reservoirs for their first year is expected to be smaller in MO3 compared to the
17120 No Action Alternative.

17121 *Juvenile Migration/Survival*

17122 The mean water temperature for May through July is estimated to be slightly warmer than in
17123 the No Action Alternative with a higher percentage of days over 20°C (35.6 percent in MO3
17124 compared to 26.6 percent in the No Action Alternative). This represents a minor increase in
17125 temperatures and days over 20°C compared with the No Action Alternative. However, the cold
17126 water flow augmentation from Dworshak is expected to be more effective with the smaller
17127 cross-sectional breached areas to cool down in July and August compared to the No Action
17128 Alternative. Major decreases in travel times would substantially reduce predation risk.

17129 An increase in nesting habitat is expected in lower Ice Harbor pool area after dam breaching.
17130 Only those islands that would not be inundated in spring flows are suitable habitat. Although a
17131 small area of nesting habitat may increase, the risk of bird predation would likely decrease as
17132 outmigrating Chinook travel times decrease and turbidity increases under MO3; these factors
17133 would reduce exposure to bird predators.

17134 One of the long-term effects of dam breaching is a higher sediment load through the free-
17135 flowing reach of river. Under MO3, the Snake River is expected to carry approximately 30 mg/L

17136 on average. Outmigrating fall-run Chinook would experience a minor decrease in predation risk
17137 under MO3 because of the decreased visibility for the predators.

17138 *Adult Migration/Survival*

17139 The dam breach measure of MO3 would reduce the delays to migration caused by temperature
17140 differential between the river and the ladders. This would be a benefit to upstream migrating
17141 fall-run Chinook.

17142 Temperatures at Ice Harbor would experience a moderate decrease with only 29.2 percent of
17143 all adult migration days over 20°C compared to 54.3 percent in the No Action Alternative.
17144 Straying and migration delays, as well as susceptibility to disease, would be reduced in MO3. All
17145 of these effects would improve survival and spawning success.

17146 Based on sediment movement analysis (see Section 3.3), excavation for the dam breach
17147 measure of MO3 would cause a large sediment plume for a long duration, that may reoccur for
17148 two to seven years after excavation. In the conceptual design proposed for analysis, the timing
17149 of dam breaching would occur during the adult fall-run Chinook migration through the Lower
17150 Snake River. Two consecutive years of construction would cause fish in this population to
17151 experience the high turbidity levels in the river. The estimated severity of the sediment pulse
17152 indicates the potential for mortality between 20 and 40 percent of fish downstream of these
17153 dams. This could result in a major short-term loss to the population, but the Snake River fall-run
17154 Chinook population would be expected to recover due to the benefits from dam breaching.
17155 Further design and mitigation measures would be developed to minimize the short-term losses.

17156 Under MO3, breaching the four Lower Snake River dams and elevated suspended sediments is
17157 estimated to cause DO levels to drop to approximately 2 mg/L throughout the Little Goose and
17158 Lower Monumental pool areas in the year of construction. Chinook salmon need over 5 mg/L of
17159 DO for survival; they become stressed at levels below this and can suffocate with prolonged
17160 lack of oxygen. If not mitigated, these levels of DO could cause the loss of major portions of
17161 migrating adult fall-run Chinook in these two pools during the peak of sediment release.

17162 MO3 would eliminate juvenile fish transportation. Scientists expect reductions in delay,
17163 fallback, and straying under MO3.

17164 ***Lower Columbia River Salmon and Steelhead***

17165 Lower Columbia River Chinook Salmon

17166 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower
17167 Columbia River Chinook salmon.

17168 *Summary of Key Effects*

17169 Juvenile survival and travel time would be similar to the No Action Alternative under MO3, with
17170 the possible exception that the fall run of Lower Columbia River Chinook salmon, which could
17171 experience higher outmigration survival through Bonneville Dam with lower spill in August.

17172 Adult migration and survival would be lower for spring-run fish due to increased spill and TDG,
17173 while fall-run fish may experience less fallback and delay. Dam breach measures in MO3 would
17174 not affect Lower Columbia River Chinook salmon.

17175 *Juvenile Fish Migration/Survival*

17176 Five of the 32 populations of Lower Columbia River Chinook salmon pass Bonneville Dam on
17177 their downstream outmigration to the ocean. Modeling was not available for this ESU;
17178 however, juvenile survival at Bonneville Dam of Snake River spring/summer-run Chinook
17179 salmon was used as a surrogate. COMPASS modeling predicts juvenile survival would have
17180 negligible increases (+0.4 percent) higher than the No Action Alternative. Much lower spill at
17181 Bonneville in August could have a minor increase in juvenile survival for fall-run Lower
17182 Columbia Chinook as powerhouse passage at powerhouse number one has a higher survival
17183 than spillway routes.

17184 Effects of outflows from March through September for all runs of Lower Columbia River
17185 Chinook salmon would be similar to the No Action Alternative. At The Dalles, water quality
17186 modeling indicates higher TDG in April through June with increased spill above the threshold of
17187 120 percent TDG for 76 days, compared to 33 under the No Action Alternative. The small
17188 proportion of this ESU that passes above Bonneville Dam may experience increased incidence
17189 of GBT during outmigration (spring-run and late-fall-run) and rearing (all runs) between The
17190 Dalles and Bonneville. Reduction of spill in August would reduce TDG to levels well below the
17191 No Action Alternative levels at this time; fall-run fish outmigrating at this time would not be
17192 affected, though they would experience the increased TDG during juvenile rearing. Below
17193 Bonneville Dam, modeling indicates the TDG would be slightly higher in the spring and
17194 considerably lower in August than the No Action Alternative, with 68 days exceeding the water
17195 quality standard compared to 61 days in the No Action Alternative.

17196 *Adult Fish Migration/Survival*

17197 Structural measures such as modifying the upper ladder serpentine sections at Bonneville Dam
17198 are expected to reduce delay associated with upstream passage. Fallback rates may decrease
17199 for fall-run and late-fall-run fish with decreased spill in August, but increase for spring-run
17200 adults. Similarly, TDG would be higher in April through June, but lower in August, so adult
17201 spring-run fish would also experience higher TDG exposure. All runs would experience higher
17202 TDG exposure for juvenile rearing. Hydrology and water quality modeling predicts flows and
17203 temperatures that could affect lower Columbia River Chinook salmon adult migration and
17204 survival would be similar to the No Action Alternative.

17205 Lower Columbia River Steelhead

17206 Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

17207 *Summary of Key Effects*

17208 Juvenile survival in MO3 would be similar to the No Action Alternative, with modeled dam
17209 survival similar to the No Action Alternative. Faster travel times with higher spill would be
17210 expected for fish that pass Bonneville Dam, but reduced flows would also slow travel time for
17211 other Lower Columbia River steelhead and potential increased TDG effects. Adult migration of a
17212 portion of the winter run could be decreased slightly with higher winter flows. Survival of kelts
17213 would be higher in spring and early summer, but lower in winter with reduced spill, and
17214 increase TDG may affect adults.

17215 *Juvenile Fish Migration/Survival*

17216 Modeling for juvenile Snake River steelhead was used as a surrogate of juvenile survival for
17217 Lower Columbia steelhead that pass Bonneville Dam. These results predict there would be no
17218 discernable difference in juvenile survival between MO3 and the No Action Alternative. TDG
17219 exposure to the fish that pass upstream of Bonneville would be higher with 43 more days above
17220 the water quality standard, and below Bonneville they would experience seven more days over
17221 the standard.

17222 *Adult Fish Migration/Survival*

17223 Structural measures such as modifying the upper ladder serpentine sections at Bonneville Dam
17224 are expected to have minor reductions in delay associated with upstream passage. Under MO3,
17225 higher spill levels during May could increase fallback and delay of a portion of winter-run
17226 steelhead. Spill reduction in August would generally reduce adult fallback and delay.
17227 Temperatures would be similar to the No Action Alternative, and adult fish would generally
17228 experience higher TDG as described for juveniles.

17229 Lower Columbia River Coho Salmon

17230 See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower
17231 Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult
17232 Lower Columbia River coho salmon.

17233 *Summary of Key Effects*

17234 Lower Columbia River coho salmon would have minor increases in juvenile survival and
17235 negligible impacts to adult salmon upstream migration under MO3, relative to the No Action
17236 Alternative.

17237 *Juvenile Fish Migration/Survival*

17238 Using the surrogate approach, CRS operational changes in MO3 may slightly increase survival
17239 rates for Lower Columbia River juvenile coho passing Bonneville Dam by as much as 1 percent.
17240 Refer to Snake River spring-run Chinook for surrogate information in Section 3.5.2.5.

17241 *Adult Fish Migration/Survival*

17242 Upstream migration and survival of adult Lower Columbia River coho salmon would have
17243 negligible impacts under MO3 compared to the No Action Alternative using surrogate
17244 information. Refer to Snake River fall-run Chinook for surrogate information in Section 3.5.2.5.

17245 Lower Columbia River Chum Salmon

17246 Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia
17247 River chum salmon.

17248 *Summary of Key Effects*

17249 MO3 is expected to result in minor increases in juvenile chum survival through Bonneville Dam
17250 and Reservoir relative to the No Action Alternative, while incubating chum sac fry would be
17251 exposed to minor increases in TDG.

17252 *Juvenile Fish Migration/Survival*

17253 As there is no direct estimate of Bonneville Dam survival specific to juvenile chum, juvenile
17254 Snake River spring-run Chinook are used as a surrogate. Under MO3, COMPASS modeling
17255 indicates that CRS operational changes are expected to result in minor increases in juvenile
17256 chum survival relative to the No Action Alternative. There is no dam-specific survival estimate
17257 available from CSS.

17258 Under MO3, chum flow operations would be met slightly more often (1 percent more) than the
17259 No Action Alternative. In years when additional releases from Grand Coulee for chum would be
17260 needed, the average additional volume needed would be 0.08 Maf.

17261 Maintaining TDG levels of 105 percent or less from November 1 to April 30 appears to provide a
17262 sufficient level of protection to chum salmon eggs and sac fry incubating in the gravel
17263 downstream of Bonneville Dam in the Ives/Pierce Island Complex, using 3 percent per foot
17264 depth compensation. In the No Action Alternative, chum sac fry are exposed to TDG above 105
17265 percent in 4 out of 80 years and those exceedances are all in the mid- to late April timeframe.

17266 *Adult Fish Migration/Survival*

17267 Most chum spawn downstream of Bonneville. Migration of chum into the Columbia River is in
17268 October and November. Adult migration and survival under MO3 would likely be similar to the
17269 No Action Alternative.

17270 **Other Anadromous Fish**

17271 ***Pacific Eulachon***

17272 Summary of Key Effects

17273 Eulachon would continue to migrate into the Columbia River from November through March,
17274 with specific dates of migration and spawning based on a variety of environmental factors
17275 including temperature, high tides, and ocean conditions (NMFS 2017). Modeled data for MO3
17276 (based on the period of record for Bonneville tailwater temperatures) indicate that
17277 temperatures would not be substantially different from the No Action Alternative. Average
17278 monthly temperatures in the winter months would be about 0.2 to 0.3 degree Fahrenheit
17279 cooler. Spawning locations and substrate conditions would not be expected to differ from the
17280 No Action Alternative.

17281 Compared to the No Action Alternative, MO3 would have no change in the time between the
17282 peak spawning runs, egg development, and larval emergence. The spring freshet that disperses
17283 larvae to adequate food sources would continue to be highly variable, with an average of 166
17284 days between spawning temperature triggers and peak flows (158 days in high flow years, and
17285 157 days in low flow years).

17286 Spring flow rates would be expected to be about 1 percent to 2 percent lower during
17287 outmigration compared to the No Action Alternative. Decreased flow can affect the chemical
17288 and physical processes of the estuary-plume environment, which affects primary productivity
17289 (NMFS 2017). The relationship between Bonneville outflow and the estuary plume is not
17290 certain, but a reduction could result in slightly less distribution of larvae.

17291 Bird predation risk can be influenced by flow rates. Higher flows are linked to higher predation
17292 rates on eulachon, whereas at lower flows birds tend to switch to marine prey. Under MO3,
17293 there would be relatively little change (1 to 4 percent) in all months and water year types (the
17294 change is low enough to be likely immeasurable). Slightly higher flows in December could
17295 increase predation risk. The early portion of the eulachon run comes in during November and
17296 December and may be more subject to predation

17297 Operation of the CRS system under MO3 would result in very similar turbidity levels in spring.

17298 ***Green Sturgeon***

17299 Summary of Key Effects

17300 The Columbia River use by green sturgeon is primarily foraging habitat for adults and subadults.
17301 Key effects of MO3 are focused on how flows and temperatures influence the cues for entering
17302 the Columbia River as well as the availability and distribution of food sources. Overall, the
17303 estuary would continue to provide good foraging and rearing habitat for green sturgeon, but
17304 there could be a minor decrease in summer foraging habitat under MO3 compared to the No
17305 Action Alternative.

17306 Adult Fish Migration/Survival

17307 Green sturgeon migrate seasonally along the West Coast, foraging in bays and estuaries during
17308 the summer and fall months, including the Columbia River estuary (as far upstream as
17309 Longview). Both southern DPS and northern DPS occur in the Columbia River, but the majority
17310 are southern DPS. The Columbia River estuary provides important foraging and rearing habitat
17311 for green sturgeon. MO3

17312 Under MO3, green sturgeon would continue to arrive in June and leave in September or
17313 October (variation compared to the No Action Alternative is one day or less in arrival/departure
17314 date). This date range would be expected to continue supporting adequate rearing conditions.

17315 Under MO3, there could be a slight decrease in summer flows (1 percent to 3 percent from
17316 June through September), but overall the estuary would continue to provide good foraging
17317 habitat for green sturgeon, but there could be a minor decrease in summer foraging habitat
17318 under MO3 compared to the No Action Alternative.

17319 ***Pacific Lamprey***

17320 Summary of Key Effects

17321 MO3 has several measures that are designed specifically to benefit lamprey. These measures
17322 are proposed structural improvements that include changing extended-length submersible bar
17323 screens, expanding the network of Lamprey Passage Structures, changing the design for turbine
17324 cooling water strainers, replacing turbines for safer fish passage, to reduce fish injury and
17325 mortality.

17326 As described for the No Action Alternative, upstream and downstream passage at the mainstem
17327 Columbia River and Snake River dams has been the greatest influence on population decline
17328 and reduced distribution of Pacific lamprey. The most substantial benefit of MO3 would be the
17329 breaching of the four Lower Snake River Dams. This would reduce mortality to lamprey during
17330 the downstream migration phase and would substantially improve the ease of upstream
17331 migration. Other key benefits would accrue through the improvements to get fish to enter the
17332 fish ladders this would occur through expanding the network of Lamprey Passage Structures
17333 and modifying fish ladders to incorporate lamprey passage criteria into the structural
17334 modifications.

17335 Larval Development/Juvenile Rearing

17336 MO3 has no measures that would either benefit or harm juvenile lamprey during the rearing
17337 stage. All ramping rates and dewatering issues would be the same in MO3 as for the No Action
17338 Alternative.

17339 Juvenile Fish Migration/Survival

17340 Under MO3, several structural measures would improve passage conditions, increase survival,
17341 and reduce injuries. Proposed actions include the following:

- 17342 • Changing the extended-length submersible bar screens to a screen material that would
17343 substantially reduce mortality due to impingement.
- 17344 • A new design of structure for exclusion of juvenile lamprey from cooling water strainer
17345 intakes would reduce or eliminate this pathway of mortality.
- 17346 • Additional powerhouse surface passage at McNary projects to change the dynamics of
17347 lamprey passage. A higher percentage of lamprey would be expected to pass via the safer
17348 surface routes instead of the turbines in relation to the No Action Alternative.
- 17349 • Replacing turbines at John Day Project with improved fish passage turbines that would
17350 improve conditions for fish passage and increase lamprey survival.

17351 Because of the high degree of uncertainty surrounding how many juvenile lamprey are lost or
17352 injured on their downstream migration, it is difficult to quantify the improvement represented
17353 by all of the measures. For fish that encounter multiple dams on their migration downstream,
17354 reducing the total number of hazards would increase their probability for survival.

17355 Adult Fish Migration/Survival

17356 Each structural measure in MO3 that targets lamprey is intended to increase their dam passage
17357 efficiency either by getting fish to enter rather than turn back from the fishway, or to increase
17358 successful upstream passage. Effectiveness of the measure would vary by dam.

17359 The most substantial benefit from MO3 would occur in the Snake River basin with breaching of
17360 the four Lower Snake River Dams. In the proposed conceptual-level designs, the river would run
17361 through the excavated earthen embankments and become free flowing in which lamprey could
17362 migrate upstream without encountering ladders or other barriers. However, hydraulic analysis
17363 shows that high velocity barriers could form at the concrete corners of the abandoned dams
17364 during high flows and early season migrants could see velocities above their burst speeds.
17365 Substrate along each of the breaches would be riprap to prevent erosion and lamprey would be
17366 expected to use burst-speed swimming over riprap.

17367 Breaching of the four lower Snake River Dams would result in faster heating and cooling of river
17368 water compared to what would occur in reservoirs in the No Action Alternative. This means the
17369 water would be warmer in early June and July, but cooler in August and September.

17370 Fluctuations would occur on diel basis (i.e., water temperatures warm up through the day and
17371 cool down at night). The fish would experience cooling in the evenings, which would lessen the
17372 overall impact to lamprey. Exposure may be reduced with faster migration times from dam
17373 breaches. July temperatures are highest when lamprey peak migrations occur.

17374 Approximately 44 percent of adult lamprey that reach Bonneville Dam pass to upstream areas,
17375 while 68 percent of those that pass Bonneville Dam will also pass The Dalles Dam (Keefer et al.
17376 2012). If the proposed structural measures were implemented at Bonneville, moderate
17377 improvements in fish passage efficiency would occur. Similar improvements at John Day ladders
17378 to improve lamprey entrance into the fishway resulted in increased passage efficiency from 46
17379 percent to 83 percent (Clabough et al. 2015). Because dynamics at each dam are very different,
17380 the improvements from the increased passage efficiency cannot be directly inferred across
17381 projects, but lamprey would see improvements in overall dam passage efficiency with
17382 improvements in ladder entrance efficiency.

17383 At John Day, lamprey passage was estimated at 67.5 percent (Keefer et al. 2019). Additional
17384 work for the Lamprey Passage Structures on the south fishway and extension on the north
17385 fishway would continue to moderately improve overall dam passage efficiency incrementally.

17386 The overall expected improvements in lamprey passage efficiency should decrease
17387 susceptibility to physical stress and mortality. These structural measures for lamprey are
17388 expected to provide a major benefit to the population size and distribution of Pacific lamprey in
17389 the Columbia Basin, and especially in the Snake River Basin due to breaching of the four lower
17390 Snake River Dams.

17391 ***American Shad***

17392 Summary of Key Effects

17393 No long-term change is anticipated to juvenile shad in the lower Columbia because plankton
17394 communities and shoreline habitat are not changing in the lower Columbia in MO3. The lack of
17395 reservoirs in the lower Snake reach would make that reach less suitable for shad than under the
17396 No Action Alternative, so an overall decrease in shad under MO3 is anticipated.

17397 Juvenile Fish Migration/Survival

17398 Plankton communities and shoreline habitat are not expected to change in the lower Columbia
17399 reservoirs relative to the No Action Alternative. However, plankton communities may be
17400 depressed in the lower Columbia reservoirs after the lower Snake dam breaches until a new
17401 plankton community equilibrium is established. During the period when plankton communities
17402 are depressed, juvenile shad are likely to face minor food reductions and may decline because
17403 their diet is almost exclusively plankton.

17404 Adult Fish Migration/Survival

17405 The proportion of adult shad counted at Bonneville Dam that migrate upstream past McNary
17406 Dam is not expected to change due to change in temperatures relative to the No Action
17407 Alternative. The breach of the lower Snake dams would facilitate upstream expansion of shad in
17408 terms of passage.

17409 **RESIDENT FISH**

17410 **Region A**

17411 ***Kootenai River Basin***

17412 Summary of Key Effects

17413 MO3 would have the same key effects as the No Action Alternative. Current discharges from
17414 Libby Dam have detrimental effects to fish species in the Kootenai River downstream of Libby
17415 Dam. Spring water temperatures would continue to be too cold for the development of many
17416 aquatic species. Spring flows would also continue to increase at a rate less than normalized,
17417 thereby delaying and reducing productivity associated with inundated riparian and varial zone
17418 habitats. These reduced flow rates would also continue to limit productivity and may adversely
17419 impact food sources for resident fish downstream of Libby Dam.

17420 Cottonwood seedlings would continue to have variable survival depending on timing, stage and
17421 duration of spring flows, along with winter stage during the ensuing winter. In addition, the
17422 discharge regime from Libby Dam would not provide for successful burbot recruitment, and
17423 spring water temperatures would be too cold to allow for proper larval development.

17424 Habitat Effects Common to This Fish Community

17425 MO3 would not change water temperatures in the spring from those under the No Action
17426 Alternative. However, similar to MO1 and MO2, MO3 would provide deeper end-of-December
17427 drafts than the No Action Alternative, with deep drafts of 11 feet in the wet years, and thus
17428 may enhance reservoir warming during the spring and early summer.

17429 MO3 would have a lower rate of flow increase from Libby Dam in the spring compared to the
17430 No Action Alternative. This decrease in flow rate under MO3 would result in a greater delay in
17431 spring productivity than under the No Action Alternative.

17432 MO3 would decrease the potential for cottonwood and willow seeding and recruitment
17433 compared to the No Action Alternative. Under MO3, there would be less area for seeding
17434 establishment than under the No Action Alternative. On average, there would be no habitat
17435 available under MO3 that is not flooded by winter scour flows compared to one foot of
17436 elevation above these flows in the No Action Alternative.

17437 MO3 would have a similar rate of recession of river stage at Bonners Ferry during the seeding
17438 seasons than the No Action Alternative.

17439 Bull Trout

17440 Effects of MO3 to bull trout that differ from the No Action Alternative include lower flows
17441 below Libby Dam and increases in usable habitat for juvenile and adult bull trout.

17442 Under MO3, Lake Koochanusa would be above elevation 2,450 feet for two more days during the
17443 summer productivity period than under the No Action Alternative. The expected result would
17444 be minor increases in productivity and an increased food web under MO3. In addition, fall
17445 water levels would be higher, on average, than under the No Action Alternative.

17446 The minimum elevation of Lake Koochanusa under MO3 would be 7 feet lower, while the
17447 maximum elevation would be 1 foot higher than under the No Action Alternative. The expected
17448 result would be greater variability in water levels and more frequent annual dewatering and
17449 decreased benthic insect production, which may result in a decrease in bull trout growth and/or
17450 survival.

17451 MO3 would have slightly lower discharges than the No Action Alternative, but would provide
17452 more usable habitat for juvenile (day and night) and adult bull trout than the No Action
17453 Alternative.

17454 Kootenai River White Sturgeon

17455 MO3 would provide an estimated one less day of peak discharge than provided by the No
17456 Action Alternative. This reduction in the ability to maximize the number of days flow exceeds 30
17457 kcfs at Bonners Ferry relative to the No Action Alternative is negligible.

17458 MO3 would provide a deeper end-of-December draft than the No Action Alternative, with
17459 drafts up to 11 feet deeper in wet years. These deeper drafts would likely lead to slightly lower
17460 productivity at Lake Koochanusa.

17461 Other Fish

17462 The median minimum elevation of Lake Koochanusa under MO3 would be 11 foot lower than
17463 under the No Action Alternative, while the maximum elevation would be 1 foot higher than the
17464 No Action Alternative. These conditions would have the same effects identified in the
17465 discussion above for bull trout.

17466 Under MO3, there would be fewer days when Libby Dam would provide a discharge of 20 kcfs
17467 or greater when compared to the No Action Alternative. These flows would be insufficient to
17468 mobilize or reshape tributary deltas that can prevent bull trout access during the fall spawning
17469 season.

17470 MO3 would have slightly lower discharges from Libby Dam from May 15 to September 30 than
17471 the No Action Alternative, but would provide slightly more usable habitat for juvenile and adult
17472 redband rainbow trout than the No Action Alternative, which may result in increased growth
17473 and/or survival of all life stages of redband rainbow trout.

17474 Effects to burbot under alternative MO3 include lower and cooler winter flows during
17475 spawning. Median flows under Alternative MO3 as measured at Bonners Ferry between January
17476 1 and April 30 would be lower than No Action Alternative. Median flows under Alternative MO3
17477 would be more likely than the No Action Alternative to provide the low and stable flows to

17478 imitate pre-dam hydrographs during burbot spawning and incubation, and thus most conducive
17479 to successful burbot recruitment. In addition, these lower flows would cool more readily than
17480 higher flows and help induce successful spawning.

17481 ***Hungry Horse/Flathead/Clark Fork Fish Communities***

17482 Summary of Key Effects

17483 The measures that affect project operations at Hungry Horse Reservoir are the same as MO1.
17484 The only difference between MO1 and MO3 is that MO3 includes the *Ramping Rates for Safety*
17485 measure, which removes ramping rate restrictions that were put in place to minimize effects.
17486 The key operational effects of MO3 (same as MO1) are largely biological responses to changes
17487 in Hungry Horse Reservoir elevations and outflows to provide additional water supply. Lower
17488 elevations through the summer would decrease food supply for fish with slight reductions in
17489 plankton production and surface area for summer terrestrial insects. Benthic insect production
17490 important to fish would be decreased under MO3. Lower surface elevations could also increase
17491 rates of predation and harvest as fish are more vulnerable in shallower water as they migrate
17492 into and out of tributaries to fulfill their life cycles. Increased outflows in summer would likely
17493 result in increased entrainment of zooplankton and fish out of Hungry Horse reservoir.
17494 Increased flows in the South Fork Flathead River would be attenuated with flows from the
17495 mainstem Flathead River but would still result in higher summer flows that would decrease
17496 native fish habitat suitability in that reach. MO3 would have negligible effects on Flathead Lake,
17497 lower Flathead River, or Clark Fork River fish.

17498 Habitat Effects Common to This Fish Community

17499 Habitat effects due to Hungry Horse Reservoir elevations would be the same as MO1. See that
17500 alternative for detailed descriptions.

17501 Because the elevation follows the same summary hydrograph as in MO1, the following
17502 parameters would also be similar:

- 17503 • End of month volume of reservoir available to produce zooplankton would be 1 to 3 percent
17504 lower in summer.
- 17505 • Magnitude and rate of drawdowns in reservoir elevation affecting benthic aquatic insect
17506 production. Benthic habitat reduced by at least 3 to 4 percent, with higher magnitude of
17507 effect in headwater bays.
- 17508 • End of month surface area influencing available surface area for terrestrial insect feeding in
17509 summer and the distance from the water surface from the terrestrial vegetation, which
17510 influences what proportion of non-flying terrestrial insects drop to the water surface to be
17511 available for fish.

17512 See Section 3.5.3.4, Multiple Objective 1, Resident Fish, Region A for detailed analyses of these
17513 relationships.

17514 Outflow patterns from Hungry Horse Reservoir would also be very similar to MO1, with higher
17515 summer flows for additional water supply and lower spring, fall, and winter flows. Therefore,
17516 flows on down the system in the South Fork Flathead River, mainstem Flathead River, Flathead
17517 Lake, lower Flathead River, and Clark Fork River would also all be the same as MO1. See Section
17518 3.5.3.4, Multiple Objective 1, Resident Fish, Region A for detailed analyses.

17519 The key difference between MO1 and MO3 is that MO3 includes the measure to remove
17520 ramping rate restrictions that have been implemented over time to reduce fish effects from
17521 ramping rates. Increased ramping rates would increase effects on aquatic insect production and
17522 potential stranding of fish. This measure is also in MO2 and habitat effects are described in
17523 Section 3.5.3.5, Multiple Objective 2, Resident Fish, Region A. One other difference is MO3
17524 outflows are lower for about two weeks in February.

17525 Bull Trout

17526 As described in the physical environment, MO3 conditions would slightly (1 to 2 percent)
17527 reduce the summer production of zooplankton that fuels the food web and surface area
17528 available for summer terrestrial insect feeding and substantially lower the benthic insect
17529 production, compared to the No Action Alternative. Reservoir elevations would be 3 to 4 feet
17530 lower in the late summer and fall in most years when bull trout migrate into tributaries and
17531 spawn, resulting in increased varial zone effects and potential tributary habitat blockage. This
17532 effect would be up to 12 feet in extremely dry years. Bull trout entrainment would be 9 to 21
17533 percent higher due to increased outflows in late summer. Zooplankton entrainment would also
17534 be 9 to 21 percent higher than the No Action Alternative so there would be more plankton
17535 available in the South Fork Flathead River, but increased flows would decrease habitat available
17536 for transitory bull trout use. Summer median flows in the mainstem Flathead River would be 2
17537 to 11 percent higher in summer than the No Action Alternative, further exacerbating issues
17538 with habitat suitability. Operations of Seli's Ksanka Qlispé' Dam (Flathead Lake) would be similar
17539 to the No Action Alternative, and the bull trout habitat use and life history functions in Flathead
17540 Lake, the Lower Flathead River, and Clark Fork River would be similar to the No Action
17541 Alternative. See Section 3.5.3.4, Multiple Objective 1, Resident Fish, Region A for more detailed
17542 analyses.

17543 Other Fish

17544 Many effects described for bull trout would also apply to all of the native fish species in Hungry
17545 Horse Reservoir. Slight decreases in zooplankton, decreased macroinvertebrates, and reduced
17546 summertime feeding of terrestrial insects could reduce food supply slightly (1 to 2 percent) in
17547 summer. Compared to the No Action Alternative, Westslope cutthroat trout and other spring-
17548 spawning native fish would experience greater varial zone effects on their way upstream as
17549 adults, and could encounter some tributary blockages, but the delta formation of these
17550 tributaries is not known. Under MO3 operations, the modeled April and May elevations would
17551 be 5 feet and 3 feet, respectively, lower than the No Action Alternative. Juveniles typically
17552 outmigrate in June when the effects would be similar to the No Action Alternative. Entrainment
17553 from the reservoir would also continue at unquantified levels and could increase nine to 21

17554 percent in the summer months with increased outflows. Habitat suitability described for bull
17555 trout would be similar for other native fish (Muhlfield et al. 2011), with higher summer flows in
17556 MO3 resulting in decreased amount of suitable habitat for them in summer. Effects to fish in
17557 Flathead Lake, the lower Flathead River, and Clark Fork Rivers would be similar as described in
17558 the No Action Alternative. See Section 3.5.3.4, Multiple Objective 1, Resident Fish, Region A for
17559 detailed analyses.

17560 ***Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River***

17561 Summary of Key Effects

17562 The key effects of MO3 for all resources in the Pend Oreille basin would be the same as those
17563 found under the No Action Alternative.

17564 Habitat Effects Common to All Fish

17565 Common habitat effects of MO3 would be the same as those identified for the No Action
17566 Alternative.

17567 Bull Trout

17568 Key effects to bull trout under MO3 are not different from the No Action Alternative.

17569 Other Fish

17570 Effects of MO3 would be the same as those identified under the No Action Alternative.

17571 **Region B**

17572 ***Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam***

17573 Summary of Key Effects

17574 Flow, elevations, and water quality affect the quality of habitat for various resident fish species
17575 above, in, and downstream of Lake Roosevelt. The Columbia River from the U.S.-Canada border
17576 would continue to support a white sturgeon population that spawns successfully but primarily
17577 relies on fish manager intervention to survive a recruitment bottleneck; conditions for natural
17578 recruitment may be further diminished in a small proportion of years. In Lake Roosevelt,
17579 retention time is a key metric for most fish species in Lake Roosevelt, driving the food web that
17580 supports the fish as well as influencing how many are entrained and would be lower in
17581 November and December than the No Action Alternative. Lake elevations under MO3 would be
17582 similar to the No Action Alternative related to risk of impeded tributary habitat access and egg
17583 desiccation/stranding for redband rainbow trout. The portion of kokanee that spawn in
17584 tributaries would continue to have access in fall similar to the No Action Alternative. The effect
17585 of egg desiccation under MO3 would remain the same for burbot and kokanee. MO3 would
17586 continue to support both wild and hatchery-raised kokanee, redband rainbow trout and

17587 hatchery rainbow trout as well as non-native warmwater game species such as walleye,
17588 smallmouth bass, and northern pike. Northern pike would likely continue to increase and
17589 invade downstream and pike suppression efforts would be at similar levels as the No Action
17590 Alternative. Rufus Woods Lake would continue to provide habitat for fish entrained from Lake
17591 Roosevelt and from limited production of shoreline spawning by some species; entrainment
17592 could increase in winter and decrease in summer months. TDG would be similar or less than the
17593 No Action Alternative.

17594 Habitat Effects Common to This Fish Community

17595 The No Action Alternative would begin a shallow drop in early January where MO3 would hold
17596 steady through January and then drop into the winter draft in February. Initiation of refill would
17597 depend on the basin's water conditions but typically would begin in early May similar to the No
17598 Action Alternative in most years except the draft may be about a foot deeper in dry years.
17599 Elevation would then rise until mid-May where they would be the same as the No Action
17600 Alternative for the rest of the water year, reaching a target full pool of about 1,289 feet by July
17601 4.

17602 Median peak outflows follow the same pattern as the No Action Alternative with slightly
17603 reduced peaks in early June and July. The MO3 median flows in early spring through September
17604 would be about 2 percent to 5 percent lower than the No Action Alternative. November and
17605 December median flows would be about 2 percent to 4 percent higher than the No Action
17606 Alternative, while January flows would be 5 percent lower. These peak outflows can influence
17607 the rate of entrainment from Lake Roosevelt into Rufus Woods Lake. TDG in the Grand Coulee
17608 tailwater is also a concern for fish in Rufus Woods Lake. Under the MO3 TDG would be lower
17609 than the No Action Alternative.

17610 Retention time of water through the reservoir is a driving metric for the food web in Lake
17611 Roosevelt and influences the populations of several fish species.

17612 Generally speaking, under MO3 median retention time would be similar to or slightly higher
17613 than the No Action Alternative in late spring, summer, and fall. In all year types, retention time
17614 under MO3 would be 2 percent to 5 percent lower in November and December. In wet years, it
17615 would be slightly lower than the No Action Alternative (one percent to three percent) in spring.
17616 In wet years is when retention time is lowest because more water is moving through the
17617 system, and MO3 would reduce spring retention times even further in these years.

17618 Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely
17619 directly on the food source provided by the zooplankton production and higher-level predators
17620 such as bull trout prey on these fish. Zooplankton are more widespread, more plentiful, and
17621 larger body size when retention times are higher, and tend to be smaller bodied, swept out of
17622 the reservoir faster, and more concentrated near Grand Coulee dam with lower retention time.
17623 With lower retention times under MO3 in winter and spring, when retention times are already
17624 fairly low, there would be less food available to fish, and they would also tend to follow the
17625 food source and crowd down towards the dam, becoming more susceptible to entrainment.

17626 Bull Trout

17627 Bull trout are temperature sensitive and would continue to use this reach for FMO habitat until
17628 temperatures reach stressful levels, which would be the same as the No Action Alternative. Bull
17629 trout in Lake Roosevelt could continue to move to cooler locations in the reservoir and these
17630 refuges would remain similar to the No Action Alternative. High flow years would continue to
17631 influence bull trout distribution through flushing more of them from the river near the U.S.-
17632 Canada border down into Lake Roosevelt. Similar to MO1, peak flows at the U.S.-Canada border
17633 were modeled showing a decrease of about 1 percent to 2 percent under MO3, which would
17634 likely be a negligible change to bull trout distribution. Increased outflows in November and
17635 December could potentially increase entrainment of bull trout, but this is negligible because of
17636 the scarcity of bull trout in Lake Roosevelt.

17637 Bull trout prey base would continue to fluctuate as the fish they eat are sensitive to changes in
17638 productivity and location of zooplankton in Lake Roosevelt. Productivity and location are
17639 influenced by the retention time of water in the reservoir, which would be adversely affected
17640 by lower retention times in winter under MO3. Bull trout are also sensitive to contaminants
17641 that are found in this region and would continue to bioaccumulate contaminants as a top
17642 predator. Reservoir operations that would increase the exposure of shorelines and contaminant
17643 uptake and fluctuation events would be the same as the No Action Alternative.

17644 Other Fish

17645 In the Columbia River reach from the U.S.-Canada border to Lake Roosevelt, white sturgeon are
17646 typically able to spawn as evidenced by capture of young of the year larvae (Howell and
17647 McLellan 2018), but rarely experience successful recruitment from larvae to juvenile sturgeon,
17648 and only in extremely high water years. Successful recruitment, as documented in 1996, 1997,
17649 and 2011, appears to be dependent on a combination of flows exceeding 200 kcfs and water
17650 temperatures of about 14°C for 3 to 4 weeks in late June/early July (Howell and McLellan 2011
17651 and Howell and McLellan 2014). Under MO3, these flows would slightly lower than the No
17652 Action Alternative. These slightly reduced flows at the U.S.-Canada border would result in
17653 potentially decreased recruitment window. The timing of these flows coinciding with lower
17654 reservoir levels can also increase recruitment ability with the longer riverine habitat provided
17655 by a lower reservoir. MO3 reservoir levels would be the same as the No Action Alternative.
17656 Recruitment window for sturgeon reproduction would be slightly reduced overall. Other factors
17657 that would continue to influence sturgeon include predation by fish that are favored by
17658 reservoir conditions if larvae are flushed into the Lake Roosevelt. Slightly lower flows in spring
17659 could slightly reduce the risk of larvae entering Lake Roosevelt. The uptake of contaminants
17660 such as copper closer to the U.S.-Canada border being flushed downstream into the reservoir
17661 by high flows would also be slightly lower. Under MO3, recruitment of white sturgeon would
17662 continue to be a rare event with slightly reduced recruitment. It would continue to be
17663 supplemented by hatchery propagation, as larval sturgeon are captured and raised in
17664 hatcheries until they are past the window where recruitment has been shown to fail at a high
17665 rate. Once these juveniles are released back into the reservoir they continue to grow and

17666 survive well. The reservoir would continue to provide good conditions for growth and survival
17667 of these fish.

17668 Wild production of native fish such as burbot, kokanee and redband rainbow trout would
17669 continue to provide valuable resources in Lake Roosevelt. As described in the common habitat
17670 effects, these fish are the most sensitive to the effects of changing retention times. Under the
17671 No Action Alternative an estimated average of over 400,000 fish annually would be entrained,
17672 with 30 to 50 percent of them being kokanee, primarily of wild origin and rainbow trout the
17673 second most entrained species. Under MO3 operations, increased entrainment would be
17674 expected in November and December as the outflows increase over the No Action Alternative
17675 and retention times would be 2 percent to 5 percent lower. Previous entrainment studies
17676 (LeCaire 2000) indicated winter being a period relatively low entrainment; however, the
17677 prolonged drawdown period is expected to increase entrainment during this time. In wet years,
17678 entrainment would also be slightly higher in March to May (one percent to two percent lower
17679 retention time) which could increase entrainment slightly. Increased entrainment of
17680 zooplankton would decrease food availability that is key to winter survival and growth of
17681 several fish species including kokanee, juvenile burbot, and other juvenile fish.

17682 For tributary spawning species such as redband rainbow trout and a portion of the wild
17683 production of kokanee, tributary access at the right time of year is important. Reservoir
17684 drawdown in the spring creates barren tributary reaches through the varial zone, which directly
17685 and indirectly impedes migration to and from tributaries and the reservoir. A lake elevation
17686 under MO3 would be sufficient to protect the access for the portion of kokanee that spawn in
17687 tributaries. Redband rainbow trout need access tributaries in the spring. Under MO3, reservoir
17688 elevations would be nearly the same as the No Action Alternative levels in the critical spawning
17689 migration time of April-May in wet years when varial zone effects are the highest due to
17690 deepest drawdowns.

17691 Species such as kokanee and burbot that spawn on shorelines in Lake Roosevelt are susceptible
17692 to egg desiccation if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on
17693 shoreline gravels September 15-October 15 and eggs incubate through February. Burbot tend
17694 to spawn successfully in depths provided by the MO3 in the Columbia River and in Lake
17695 Roosevelt on shorelines near the Colville River in winter with eggs incubating through the end
17696 of March (Bonar et al. 2000). MO3, compared to the No Action Alternative, would reduce the
17697 desiccation of eggs slightly because the reservoir holds slightly longer January in average years.
17698 Dry years could see minor changes with January levels in this 20 percent of years expected to
17699 drop slightly lower than the No Action Alternative, as well as a short-term reduction in levels
17700 during late November.

17701 Burbot spawn later in the winter and would have similar effects as the No Action Alternative,
17702 except for the slight improvement noted in average years in January. Burbot spawn in the
17703 Columbia River above Lake Roosevelt and in reservoir towards the upper end; the river
17704 spawning fish would not be as susceptible to reservoir fluctuations and would be similar to the
17705 No Action Alternative.

17706 Kokanee are very sensitive to water temperature, and during summer are found at depths
17707 below 120m to find suitably cool water. Under the No Action Alternative, Lake Roosevelt is very
17708 weakly stratified but does have suitably cool water at this depth along with suitable levels of
17709 dissolved oxygen. Lake whitefish and mountain whitefish also likely use this cool water in the
17710 summer.

17711 Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish,
17712 crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all
17713 tolerate a wide range of environmental conditions and would continue to contribute to the
17714 fishery community under the MO3, and continue to adversely impact native species via
17715 predation. The invasion downstream by northern pike is of concern, and the Lake Roosevelt Co-
17716 Managers are actively suppressing pike populations using gillnets set by boats as soon as they
17717 can get on the water in the spring until the boat ramp becomes unusable at elevation of 1,235
17718 feet. Under the No Action Alternative this occurs on April 15 in wet years, boat ramps remain
17719 useable in dry and average years. This would be the same in MO3. It should be noted that is
17720 only one boat ramp, but the middle of Lake Roosevelt area becomes inaccessible earlier, at lake
17721 elevation 1,245'. Additionally, outflows and retention time would continue to influence the
17722 entrainment and downstream invasion of non-native gamefish below Chief Joseph Dam where
17723 ESA-listed anadromous salmonids would be susceptible to predation by them. During the time
17724 when pike juveniles would be most susceptible to entrainment (May to August), retention time
17725 under MO3 would be similar or slightly higher so entrainment risk for pike would be similar to
17726 the No Action Alternative or slightly lower.

17727 Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt
17728 would experience similar effects as their native counterparts except for spawning and early
17729 rearing effects. In addition, the net pen locations are situated where the water quality can be
17730 affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG,
17731 and their eventual recruitment to the fishery can be affected by retention time coupled with
17732 reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May.
17733 Under the MO3, the water quality at these locations would be similar to the No Action
17734 Alternative, and the retention time in May would be either similar or slightly higher so
17735 entrainment risk would be the same as the No Action Alternative or slightly less. The net pen
17736 operators strive to release these fish to coincide with the initiation of reservoir refill when
17737 outflows are reduced, which under MO3 would be the same as the No Action Alternative, so
17738 these fish would continue to be release when water quality conditions would be suitable.

17739 The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake
17740 Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter
17741 drawdown periods. The increased flows and shorter retention times in November and
17742 December may increase entrainment and boost populations in Rufus Woods Lake, where
17743 decreased outflows in August and September likely would decrease entrainment. This lake has
17744 more riverine characteristics with steep gradients and narrow canyon walls, making it more like
17745 a river than a reservoir, with short retention time and low productivity. High flows during late
17746 spring and early summer would continue to flush eggs and larvae from protected rearing areas

17747 similar to the No Action Alternative, but slightly lower magnitude. Median peak outflows occur
17748 in early June and would be about 3 percent lower than the No Action Alternative. TDG in the
17749 Grand Coulee tailwater is a concern for fish in Rufus Woods Lake; modeling showed TDG would
17750 be lower than the No Action Alternative.

17751 ***Chief Joseph to McNary Dam***

17752 Summary of Key Effects

17753 Key effects under MO3 that differ from those of the No Action Alternative would be the long-
17754 term restoration of fragmented populations of white sturgeon. There would be slight
17755 reductions in flows and minor reductions in productivity in the McNary reservoir for two to
17756 seven years following the breaching of the four lower Snake River dams. Connectivity of the
17757 Columbia River with the Snake River would increase. Increased white sturgeon spawning and
17758 recruitment, minor increases in turbidity below the Snake and Columbia River confluence, and
17759 slight reductions in smallmouth foraging success are also expected.

17760 Habitat Effects Common to All Fish

17761 Under MO3, the breaching of the four lower Snake River dams would lead to an increase in
17762 spring sediment levels in the McNary pool below the confluence of the Snake and Columbia
17763 Rivers. There would be a substantial increase in connectivity of the Columbia River with
17764 mainstem riverine habitats on the lower Snake River.

17765 Bull Trout

17766 Key effects to bull trout under MO3 would not differ from those of the No Action Alternative.

17767 Other Fish

17768 Effects to white sturgeon from MO3 are similar to those of the No Action Alternative. However,
17769 under this alternative there would be slight reductions in high flows of May and June,
17770 potentially leading to minor reductions in white sturgeon spawning success. In addition, white
17771 sturgeon require large sections of riverine habitat for successful spawning and recruitment.
17772 Under MO3, there would be a major increase in connectivity of riverine habitats for white
17773 sturgeon. Populations in the McNary pool and Hanford reach would have access to hundreds of
17774 miles of the lower Snake River, up to Clearwater River and the Hells Canyon complex.

17775 Key effects to fish species in this reach under MO3 would include a slight reduction in
17776 productivity of the McNary pool downstream from the Snake River confluence for two to seven
17777 years. Deposition of sediments in McNary pool following the breaching of the four lower Snake
17778 River dams would increase. There is a potential reduction in foraging success of smallmouth
17779 bass due to increased turbidity during breaching and during runoff and heavy rain events.
17780 Following the breaching of the four lower Snake River dams there would be a reduction in
17781 downstream drift of small fish and aquatic invertebrates that would reduce forage for resident
17782 fish from two to seven years. While breaching, and during high runoff or rain events shortly

17783 following breaching, large quantities of sediment would be deposited in the McNary pool just
17784 below the confluence of the Snake and Colombia River. This sediment would alter these
17785 habitats by silting in gravel coble habitats and reducing the benthic organisms that depend on
17786 them. Increased turbidity is associated with reduced foraging success of smallmouth bass and
17787 other visual feeders. Under MO3, there would be an increase in seasonal turbidity in the
17788 McNary pool from sources upstream in the Snake River. Smallmouth bass foraging success
17789 would be reduced by some unknown amount during runoff and heavy rainfall events.

17790 **Region C**

17791 ***Snake River Basin***

17792 Summary of Key Effects

17793 Key effects to resident species under MO3 can be broken into short and long-term effects.
17794 Short term effects include high sediment and low oxygen concentrations that would likely lead
17795 to the loss of most of the fish in this reach during breaching, reduced forage and productivity
17796 for 2 to 7 years following breaching, and potential migration barriers at tributaries that may
17797 become perched during reservoir drawdown. Long-term effects would likely include changes in
17798 water temperature regimes with warmer water temperatures in the spring and cooler water
17799 temperatures in the fall, changes in resident fish communities from reservoir to riverine
17800 species, improved fish passage and habitat connectivity, major reductions in TDG, and
17801 improved spawning habitat of river spawning species.

17802 Habitat Effects Common to All Fish

17803 Under MO3, habitats would change considerably. Water velocities in the lower Snake River
17804 would increase nearly tenfold shifting the fish community to one dominated by riverine species.
17805 Substrates would revert to more cobble gravel and less silt and sand, and water levels (river
17806 stage) would have greater seasonal variation.

17807 Bull Trout

17808 The breaching of the four lower Snake River dams under MO3 would result in short- and long-
17809 term changes to bull trout use in the lower Snake River as compared to the No Action
17810 Alternative. Low numbers of bull trout would continue to use the lower Snake River as a
17811 migration corridor and for foraging and overwintering from November through June. However,
17812 breaching of the dams would allow for easier passage and better connectivity between
17813 populations. High suspended sediment levels and very low DO levels during dam breaching and
17814 the years following would adversely affect bull trout. Any bull trout in the river at that time may
17815 experience elevated levels of mortality. Overall water temperatures following dam breaching
17816 would be cooler for much of the year. However, May and June water temperatures would be
17817 higher.

17818 Because breaching would occur about a month before bull trout would be entering the
17819 mainstem Snake River in the fall, potential passage effects from construction may be reduced.
17820 In the short term, passage into the tributaries may be adversely affected as sediment deposits
17821 may prevent bull trout from re-ascending tributaries in the spring.

17822 Bull trout would no longer be entrained at the dams and would not need to use fish ladders to
17823 move upstream. High flows in the river may cause seasonal velocity barriers for bull trout at the
17824 dam sites when water reaches velocities over 12 feet per second as it passes through the
17825 breached portion of the dams. However, the remaining dam structures may provide foraging
17826 areas for bull trout as they overwinter and during migrations.

17827 Because the volume of water would be reduced, water temperatures would change faster in
17828 response to environmental inputs (i.e., warmer air temperatures or cold snowmelt). Water
17829 temperatures are expected to warm sooner in the spring, and cool earlier in the fall. Daily water
17830 temperature fluctuations would be larger as well. Overall, yearly water temperatures would be
17831 cooler and more suitable for bull trout, resulting in reduced stress and improved survival.
17832 However, water temperatures would be higher in June and July and may induce bull trout to
17833 migrate from to cooler tributary habitats earlier in the year. Under MO3, TDG levels would be
17834 reduced to 104 to 105 percent year-round. This reduction in TDG would benefit bull trout.

17835 Immediately following breaching of the lower Snake River dams, suspended sediment loads in
17836 the Snake River would be greatly increased and DO decreased relative to the No Action
17837 Alternative. DO levels in the river at that time would be low enough that any bull trout in the
17838 mainstem could experience increased levels of mortality. As suspended sediment levels
17839 decrease, DO levels would return to normal levels that would support bull trout. Long-term
17840 effects of MO3 would include elevated sediment during the spring freshet the year following
17841 dam breaching. These conditions may adversely affect bull trout.

17842 Unlike the No Action Alternative, under MO3 there would likely be a temporary reduction in
17843 forage for bull trout. As river flows clean the sediment from embedded cobble and gravel,
17844 invertebrate populations would expand and productivity would increase. This reduced
17845 productivity is estimated to be about 2 to 7 years. Forage fish and invertebrates would be
17846 expected to increase over time. The change of the food base from zooplankton to
17847 macroinvertebrates in the river would benefit sub-adult bull trout.

17848 White Sturgeon

17849 The breaching of the four lower Snake River dams under MO3 would increase connectivity
17850 between McNary Reservoir, Hells Canyon, and spawning habitat in the lower Snake River.
17851 Short-term effects would include high levels of suspended sediment and very low DO levels
17852 during dam breaching. Any white sturgeon in the river at that time may experience increased
17853 levels of mortality.

17854 Spawning of white sturgeon in the Snake River basin under MO3 would change relative to the
17855 No Action Alternative. The breaching of the four lower Snake River dams would increase the

17856 amount of spawning habitat available in this reach and produce higher water velocities that
17857 would induce spawning. Suitable spawning substrates would expand from an estimated 226 to
17858 3,521 acres under a breach scenario. Modeling shows that average velocities in a breached
17859 scenario would reach between 6 and 8 ft/sec during the spring runoff compared to less than 1
17860 ft/sec under the No Action Alternative. These conditions would lead to more successful
17861 spawning and recruitment for white sturgeon.

17862 Water temperatures in the lower Snake River under MO3 would change from those of the No
17863 Action Alternative. Water quality modeling shows that water temperatures would likely be 2 to
17864 4 degrees Fahrenheit warmer in June and July and 2 to 4 degrees Fahrenheit cooler in
17865 September through December under this alternative. Earlier warming may induce adults to
17866 spawn earlier and reduce any adverse effects. Water temperatures in the lower Snake River
17867 would continue to be suitable for egg incubation under MO3. However, more days would likely
17868 exceed optimum temperatures for egg incubation than under the No Action Alternative.

17869 The ability of the Snake River to provide rearing habitat for the yolk sac larvae and juvenile
17870 white sturgeon under MO3 would be different in both the short and the long term from that
17871 under the No Action Alternative. In the short term, release of sediments during dam breaching
17872 would temporarily cover cobble and gravel substrates with silt and sediment, reducing hiding
17873 cover for sturgeon sac fry and invertebrates that provide forage for juvenile sturgeon. The
17874 substrate would be scoured clean in two to seven years and would likely improve habitat for
17875 both spawning and rearing long term. River mechanics modeling (see Section 3.3) shows that
17876 following dam breaching, currently existing sediment deposits would likely be scoured to the
17877 original riverbed.

17878 Migration of white sturgeon through the lower Snake River would improve in the long term
17879 under MO3. Breaching of the four dams would reconnect white sturgeon populations from
17880 McNary Reservoir to Hells Canyon. Movement between populations would be unrestricted and
17881 spawning habitat would increase. Recruitment would also likely increase. In the short term,
17882 there would be no upstream passage, as water quality conditions during dam breaching may
17883 not support sturgeon passage.

17884 TDG levels would be greatly reduced under MO3 relative to the No Action Alternative. Under
17885 this alternative, TDG conditions would be ideal for most of the lower Snake River as there
17886 would be no spill at the four dams to raise TDG levels. Modeling shows under MO3 TDG levels
17887 would not exceed 110 percent at any time during the year, and that the highest TDG level
17888 would be approximately 104 percent. No adverse effects from TDG on white sturgeon are
17889 expected under MO3.

17890 The effects of suspended sediment loads in the Snake River reservoirs on white sturgeon under
17891 MO3 would be very different from those under the No Action Alternative. During, and
17892 immediately following, breaching of the lower Snake River dams, suspended sediment loads in
17893 the Snake River would increase up to 25,000 mg/l for a short period of time and loads of about
17894 5,000 mg/l for may extend for 18 to 26 days following each of the dam breaching events. These
17895 sediment concentrations would result in a 20 to 40 percent mortality of white sturgeon.

17896 Further, chemical and biological oxygen demands associated with dam breaching and the
17897 increased suspended sediment could lower DO levels in the river to 2 ppm. Short-term effects
17898 to white sturgeon could result in periods of significant mortality. The loss of mature adult fish
17899 would be a major adverse effect. As suspended sediment levels decrease, DO levels would
17900 return to normal levels that would support white sturgeon.

17901 The breaching of the Snake River dams under MO3 would have a much greater potential to
17902 affect contaminant levels in the river than the No Action. Dam breaching would re-entrain
17903 dormant sediments that may contain elevated concentrations of heavy metals, pesticides, and
17904 other chemicals of concern. These chemicals of concern would have an unknown impact on
17905 white sturgeon

17906 Other Fish

17907 Effects to resident fish from MO3 that differ from those of the No Action would include the loss
17908 of fish and invertebrates during and shortly following dam breaching, an increase in mean
17909 water velocity, the conversion of reservoir habitats to riverine habitats, a reduction in TDG
17910 levels, an increase in spawning habitat for riverine species, and changes in water temperature
17911 regimes.

17912 Effects from MO3 can be broken into short- and long-term effects. Short-term effects to
17913 resident fish species from dam breaching would include elevated sediment concentrations and
17914 reduced oxygen levels. Sediment levels may reach 25,000 mg/l for short periods of time and
17915 over 5,000 mg/L for 18 to 20 days. Similar to bull trout, these levels of suspended sediment may
17916 induce mortality rates between 20 and 60 percent for resident fish depending on the species.
17917 Chemical and biological oxygen demands associated with dam breaching and the increased
17918 suspended sediment could lower DO levels in the Snake River to approximately 2 ppm. These
17919 reduced oxygen concentrations could result in significant levels of mortality in the lower Snake
17920 River. Short-term effects could also include the loss of macroinvertebrate or significant
17921 reductions to populations that provide forage for most of the resident fish community. This
17922 reduced forage base is expected to last between two and seven years as flows from a new river
17923 scour embedded substrates that would house invertebrate populations.

17924 Long-term effects from MO3 would include large decreases in TDG concentrations and altered
17925 water temperature regimes throughout the lower Snake River. Under MO3 TDG is not expected
17926 to reach 105 percent and risk of GBT to resident fish would be reduced. Water temperatures
17927 under this alternative would be 2 to 4 degrees Celsius warmer in spring and 2 to 4 degrees
17928 Celsius cooler in the fall. These changes in temperature may alter spawn timing and success for
17929 resident fish species.

17930 Under MO3 there would be major changes in aquatic habitats available to resident fish species.
17931 Large reductions in slow water habitats would occur with major shifts to riverine habitats. One
17932 important metric to measure these changes is water velocity. Mean annual water velocity
17933 would increase from less than 0.5 ft/sec under the No Action Alternative to about 4 ft/sec
17934 under MO3. This increase in velocity would alter the fish community such that reservoir-

17935 dependent species would be reduced and riverine species would increase. Relative abundance
17936 of walleye, crappie, and northern pikeminnow would decline under MO3, while concentrations
17937 of smallmouth bass would remain the same or increase slightly and the abundance of white
17938 sturgeon would increase. Changes in habitat would include increased spawning habitats for
17939 riverine species while slow water rearing habitats would be reduced to backwater and side
17940 channel areas.

17941 The change from reservoir to riverine habitats under MO3 would also alter the productivity and
17942 forage base for resident fish species. Forage resources would convert from a zooplankton-
17943 dominated reservoir to an insect-dominated river. Zooplankton are expected to drop to less
17944 than 10 percent of the current biomass and would be replaced, in time, with
17945 macroinvertebrates. Productivity is expected to be reduced during the dam breach but would
17946 slowly return over time.

17947 **Region D**

17948 ***Mainstem Columbia River from McNary Dam to the Estuary***

17949 Summary of Key Effects

17950 Bull trout would continue to use the Columbia River in limited numbers and seek cold water
17951 refuge available at the mouths of tributaries. White sturgeon would continue to successfully
17952 reproduce in years with adequate flow and temperature conditions.

17953 Habitat Effects Common to this Fish Community

17954 Outflows from McNary Reservoir influence some of the fish relationships described in this
17955 section. Peak spring flows affect habitat maintenance for some species. Modeled median
17956 outflows for MO3 indicate that outflows would be within 3 percent of the No Action Alternative
17957 (no discernable change).

17958 Other flow parameters referred to in this section refer to outflows of McNary Dam, which are
17959 indicative of flows on downstream through the other Projects.

17960 Bull Trout

17961 Bull trout are known to use the mainstem Columbia River to move between tributaries and
17962 have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et
17963 al. 2016). Water temperature is the most important habitat factor for bull trout in the
17964 mainstem Columbia. Under MO3, bull trout would continue to use the mainstem Columbia for
17965 migration between tributaries, as well as tributary mouths for passage and thermal refugia.

17966 Adult bull trout move downstream during fall and overwinter in reservoirs (October to
17967 February; Barrows et al. 2016). Although bull trout successfully move between areas on the
17968 mainstem, their migration can be delayed at the dams. MO3 includes structural measures for
17969 additional spillway passage at McNary Dam. This measure would be in operation from March 1

17970 through August 31, and could slightly improve bull trout downstream passage, but the majority
17971 of adult bull trout would have moved out of the mainstem by the time this surface passage
17972 route would be in use.

17973 Passage through turbines can cause injury or mortality MO3 includes turbine replacement with
17974 IFP turbines, which would improve survival (Deng et al. 2019). At John Day, turbine replacement
17975 would provide safer passage for any bull trout that move through the dam.

17976 Bull trout would continue to be subject to bird predation.

17977 Other Fish

17978 Under MO3, white sturgeon spawning and recruitment would be similar to the No Action
17979 Alternative. In low flow years, it is likely that there is very little spawning and recruitment, but
17980 overall conditions would be similar to the No Action Alternative.

17981 Model results indicate suitable spawning temperatures would be similar to the No Action
17982 Alternative. In years of low flow conditions, water temperatures could increase beyond the
17983 suitable range by early June, resulting in little or no recruitment.

17984 White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse
17985 substrates (Parsley et al. 1993). Dam breaching upstream under MO3 could result in some
17986 amount of sediment increase downstream.

17987 Lack of effective upstream white sturgeon passage for all age classes decreases the connectivity
17988 of the population (Parsley et al. 2007). Under MO3, a measure to improve fish passage at
17989 Bonneville Dam would likely improve potential passage for sturgeon. The vertical slot fishway
17990 could make it easier for sturgeon to pass upstream.

17991 Turbine units at dams can cause injury and mortality in juvenile and adult sturgeon. Under
17992 MO3, improvements to turbines at John Day would reduce injuries and mortality of sturgeon
17993 (Deng et al. 2019).

17994 White sturgeon larvae are adversely affected by TDG. Studies have shown high rates of altered
17995 buoyancy at 118 percent TDG, and 50 percent mortality at 131 percent TDG (Counihan et al.
17996 1998). Adults are more able to compensate for increased TDG by moving to lower depths, but
17997 larvae in shallow water would be more adversely affected. Under MO3, TDG rates would be less
17998 than the No Action Alternative at McNary and Bonneville Dams in August but would be higher
17999 at The Dalles and Bonneville from mid-April through mid-June. Since the earlier spring months
18000 are when larvae would be more likely to be present, overall this would be a represent a minor
18001 increase in adverse effects compared to the No Action Alternative.

18002 Under MO3, pool elevations could be about 1 foot higher in the John Day pool, which provides
18003 more habitat for juveniles, but subsequent drops in elevation could lead to juvenile stranding.
18004 MO3 may result in increased sediment transport through the lower Columbia River and
18005 increase sedimentation in these reservoirs.

18006 Under MO3, no changes to resident fish communities would be expected. As shown above,
18007 outflow rates below McNary Dam would be very similar to the No Action Alternative. Water
18008 quality and food availability would also be similar to the No Action Alternative.

18009 Conditions that promote lower water temperatures and higher spring flows tend to lower the
18010 survival rates of warmwater game fish, potentially lowering populations of predators on salmon
18011 and steelhead. MO3 would be expected to continue supporting warmwater game fish at levels
18012 similar to current conditions.

18013 **MACROINVERTEBRATES**

18014 Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under MO3. For more
18015 detailed information on the effects of MO3 on aquatic invertebrates and implications on food
18016 web interactions see the Habitat Effects section of these respective fish community analyses in
18017 the Resident Fish section under the applicable region.

18018 **Region A**

18019 Project operations under MO3 would affect the aquatic environments provided by Hungry
18020 Horse Reservoir, South Fork Flathead River, Flathead River, Flathead Lake, lower Flathead River,
18021 Clark Fork River, Lake Pend Oreille, Pend Oreille River, Lake Kootenai, and the Kootenai River.
18022 Hungry Horse Reservoir and Albeni Falls Reservoir operations would both be the same under
18023 MO3 as MO1 and effects to aquatic macro-invertebrates would be the same (see Section
18024 3.5.2.3 for a discussion of the macroinvertebrate effects under MO1).

18025 Hungry Horse reservoir would experience increased dewatering of insects through the summer
18026 because of reduced varial zone habitat. Lower summer elevations would also result in
18027 decreased summer zooplankton production, and increased release of zooplankton out of the
18028 reservoir and into the South Fork Flathead River with higher outflows. South Fork Flathead
18029 River flows could increase zooplankton levels and wetted area for macroinvertebrate
18030 production in the South Fork Flathead River but could also flush more out of this area with
18031 higher velocities. MO3 operations would result in negligible changes to Flathead Lake, the
18032 lower Flathead River, and the Clark Fork River. These habitats would continue to support the
18033 macroinvertebrates described in the affected environment.

18034 The operations of Albeni Falls Project would be very similar to the No Action Alternative and
18035 MO1 operations and would not result in appreciable changes to Lake Pend Oreille or the Pend
18036 Oreille River, nor the macroinvertebrate communities in those habitats.

18037 In the Kootenai basin, MO3 operations would diverge from the No Action Alternative with
18038 deeper, steeper drafts in winter. Summer elevations would be similar to MO1. Lake Kootenai
18039 would be held above elevation 2450 from one to two more days than the No Action Alternative,
18040 which would result in similar overall productivity of zooplankton and macroinvertebrates in the
18041 system.

18042 **Region B**

18043 The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic
18044 insects such as stonefly, caddisfly, and mayfly larvae. The river elevation in this reach is
18045 influenced by Lake Roosevelt operations and inflows so is somewhat variable, which would
18046 constrain benthic production to some degree.

18047 MO3 river stage at the U.S.-Canada border and downstream into Lake Roosevelt would be the
18048 same as the No Action Alternative. Macroinvertebrate habitat would not be affected. In Lake
18049 Roosevelt, the elevations would also be the same as under the No Action Alternative, with the
18050 minor exception that the winter elevation would be held level about two weeks longer than
18051 under the No Action Alternative, just prior to the winter draft. This would be a slight benefit to
18052 aquatic invertebrate production.

18053 In Lake Roosevelt, the production, distribution and persistence of zooplankton is highly variable
18054 and sensitive to how long the water stays in the reservoir (retention time), which is a function of
18055 inflows, reservoir volume, and outflows. Longer water retention times allow for more and
18056 larger-bodied zooplankton to be more widely distributed throughout the reservoir. Lower
18057 retention times result in fewer and smaller-bodied zooplankton that get concentrated near the
18058 dam, where they would be subject to high rates of entrainment. Generally speaking, under
18059 MO3 median retention time would be similar to or slightly higher than the No Action
18060 Alternative in late spring, summer, and fall. In all year types, retention time under MO3 would
18061 be 2 percent to 5 percent lower in November and December. In wet years it would be slightly
18062 lower than the No Action Alternative (1 percent to 3 percent) in spring. In wet years retention
18063 time is generally lowest because more water is moving through the system, and MO3 would
18064 reduce spring retention times even further in these years.

18065 Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with
18066 steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short
18067 retention time and low productivity. Aquatic insect production and desiccation, river stage at
18068 RM 594 in Rufus Woods Lake would follow the same pattern and magnitude changes under
18069 MO3 as the No Action Alternative. The stage would be slightly lower (less than a half of a foot)
18070 through the spring, but the change to macroinvertebrate habitat would likely be negligible.

18071 **Region C**

18072 Dworshak Reservoir elevations would be the same as the No Action Alternative. Benthic
18073 production in the reservoir would continue to be low due to the extensive variation in water
18074 surface elevation, near-shore wave action that causes erosion, and the lack of aquatic plants
18075 along the shoreline. Likewise, outflows would be the same as the No Action Alternative. Benthic
18076 communities in the Clearwater River below Dworshak Reservoir would continue to be limited
18077 by unsuitably high flows in summer and late winter.

18078 The breaching of the four lower Snake dams would result in a shift to macroinvertebrate
18079 communities. Organisms in the rivers downstream of breach sites would likely experience

18080 substantial mortality in the short-term immediately following breach due to elevated
18081 suspended sediment and major reductions in dissolved oxygen that would move downstream
18082 (see Section 3.4, *Water Quality*). Over time, as the river reached a state of equilibrium,
18083 conditions would be shifted from reservoir habitats to more natural riverine habitats. Species
18084 richness would likely increase over time. Opossum shrimp and Siberian prawns would likely be
18085 reduced in numbers as they favor slow-moving lake habitats. The rock and riprap substrate that
18086 provide crayfish habitat would be reduced as dam sites and other structures would be
18087 dewatered. As the river flows cleared out accumulated sediments over the course of several
18088 years, there would be a shift from more soft sediment habitat dominated by worms to more
18089 hard habitats with a higher diversity of aquatic macroinvertebrates. Mussels, clams, and snails
18090 that prefer lake habitats would be reduced.

18091 **Region D**

18092 MO3 would result in only minor changes to flows or temperatures that could affect
18093 macroinvertebrate communities in the lower Columbia River. Very little benthic
18094 macroinvertebrate information is available for the lower Columbia River. Lake habitats in the
18095 impounded reaches would continue to support a low diversity of worms, benthic insects, and
18096 mollusks. The breach of Snake River dams could result in increased sedimentation in some
18097 areas of the lower Columbia River, possibly resulting in a species shift of more worms, mollusks,
18098 etc. that prefer soft substrates in these localized areas. The run of river dams would continue to
18099 be operated at stable elevations that would continue production of these aquatic
18100 macroinvertebrates.

18101 **SUMMARY OF EFFECTS**

18102 **Anadromous Fish**

18103 Model results indicate that the breaching of the four lower Snake River projects is expected to
18104 have major beneficial effects on juvenile outmigration and adult upstream migration. This MO
18105 would end juvenile transportation from the Snake River and would likely lead to a transition in
18106 hatchery mitigation tied to those dams as described in the mitigation measures in Chapter 5.

18107 Under MO3 there is a slight increase predicted in upper Columbia spring Chinook salmon in-
18108 river survival and no change to steelhead relative to the No Action Alternative. These changes
18109 are primarily due to increased spill levels in the lower Columbia River. CSS model results were
18110 not available (no model results were able to be produced) for upper Columbia River species in
18111 this EIS. Results from the NOAA LCM indicate that the level of improvement to upper Columbia
18112 spring Chinook SARs is dependent on the level to which latent mortality affects this stock. If
18113 increased spill in the lower Columbia River does not improve ocean survival, (i.e. reduce latent
18114 mortality) the LCM model predicts negligible to minor improvements in SARs (one percent
18115 relative increase). Larger reductions in latent mortality would result in larger predicted
18116 increases in both SARs and abundance for Upper Columbia stocks (4 to 147 percent relative
18117 increase in abundance).

18118 Quantitative model results from both the CSS and LCM were available indicated a range of
18119 potential long-term outcomes largely due to how the models address latent mortality. The CSS
18120 models predict that outmigrants from Lower Granite that return to Lower Granite (SARs) would
18121 increase by 170 percent relative to the No Action Alternative. The NOAA LCM predicted that
18122 SARs from Lower Granite to Bonneville would improve by 14 percent relative to the No Action
18123 Alternative. The CSS model predicted similar improvements for Snake River steelhead. NOAA
18124 did not produce LCM model estimates for Snake River steelhead.

18125 MO3 is also expected to provide a long-term benefit to species that spawn or rear in the
18126 mainstem Snake River habitats, such as fall Chinook. By breaching the four lower Snake River
18127 dams, major short-term adverse impacts to fish, riparian and wetland habitat in the Snake River
18128 and confluence of the Columbia River would occur, associated with the initial breaching the
18129 dams, drawing down the reservoirs, and time for the river to move sediment and stabilize.
18130 These effects are expected to diminish over time. MO3 also includes structural modifications to
18131 infrastructure at the dams to benefit passage of adult salmon, steelhead, and Pacific lamprey.

18132 Maximum summer water temperature would increase slightly; water temperature variability
18133 would increase; and water temperatures would not stay cool as long into the spring and would
18134 cool earlier in the fall with the removal of the thermal inertia of the lower Snake dam
18135 reservoirs. In general, anadromous species not migrating to or from the Snake River may see
18136 minor changes in passage through the lower Columbia River, while effects to Snake River
18137 species are expected to be major and beneficial once short term adverse effects associated
18138 with dam removal have subsided.

18139 **Resident Fish**

18140 Habitat effects outside of the Snake River would remain minor and similar to those in MO1. In
18141 Region A, higher lake elevations under MO3 would result in higher productivity at areas such as
18142 Lake Koochanusa, while effects at Hungry Horse would be similar to MO1 (minor to moderate
18143 adverse due to reduced food productivity in summer and lower lake elevations). In Region B,
18144 the effects to Lake Roosevelt are expected to be minor when compared to the No Action
18145 Alternative. Winter drawdown is expected to increase entrainment, but the varial
18146 zone/tributary access impacts are comparable to the No Action Alternative. In Region C, long-
18147 term effects would likely include changes in water temperature regimes with warmer water
18148 temperatures in the spring and cooler water temperatures in the fall, changes in resident fish
18149 communities from reservoir to riverine species, improved fish passage and habitat connectivity,
18150 major reductions in TDG, and improved spawning habitat of river spawning species. Short term
18151 effects include high sediment and low oxygen concentrations that would potentially lead to the
18152 elevated mortality for fish in this reach during breaching, reduced forage and productivity for 2
18153 to 7 years following breaching, and potential migration barriers at tributaries that may become
18154 perched during reservoir drawdown. These adverse short-term effects and beneficial long-term
18155 effects in the Snake River are expected to be major. Effects in Region D would be minor adverse
18156 to negligible.

18157 **Macroinvertebrates**

18158 Habitat effects outside of the Snake River would remain minor and similar to those in MO1. All
18159 organisms in the rivers downstream of breach sites would likely experience substantial
18160 mortality in the short-term immediately following breach due to the pulses of sediment
18161 traveling downstream. At Libby Dam, high flows would decrease the potential for cottonwood
18162 and willow seeding and recruitment. Structural changes at McNary and John Day would
18163 improve passage for bull trout and other species. Over time, as the river reached a state of
18164 equilibrium, conditions would be shifted from the reservoir habitat to more natural riverine
18165 habitats. Species richness would likely increase over time, with a shift toward species preferring
18166 riverine habitats. These adverse short-term effects and beneficial long-term effects in the Snake
18167 River are expected to be major.

18168 **3.5.3.7 Multiple Objective Alternative 4**

18169 **ANADROMOUS FISH**

18170 **Salmon and Steelhead**

18171 Several different ESU/DPS units of salmon and steelhead share a similar life cycle and
18172 experience similar effects from the MOs, but also have ESU/DPS specific traits that specifically
18173 drive effects differently from one another. Common effects analyses across all salmon and
18174 steelhead are discussed first, and then those ESU/DPS specific effects are displayed.

18175 ***Effects Common Across Salmon and Steelhead***

18176 Summary of Key Effects

18177 MO4 includes several structural and operational measures intended to improve juvenile salmon
18178 and steelhead migration and survival, including incremental improvements in powerhouse
18179 surface passage routes and improved survival of fish that go through the turbines. Increases in
18180 spill, drawing down lower river reservoirs, and additional flow augmentation in dry years are
18181 expected to decrease the travel time of in-river fish, and decrease powerhouse encounter
18182 rates, but TDG exposure would increase. Fewer smolts would be transported. Adult migration
18183 would be enhanced by structural measures to reduce delays in the Snake River projects, and
18184 steelhead kelt survival would be improved with the addition of spillway weir notch inserts, but
18185 adult delays and fallback may be increased with more spill. In the balance between survival
18186 benefits of transporting fish compared to increasing the speed and survival of in-river fish, MO4
18187 leans towards less transport and increasing the number of fish migrating in-river. The overall
18188 benefits to abundance of returning salmon and steelhead would depend on the degree to
18189 which latent mortality affects ocean survival of in-river fish. Unless otherwise noted,
18190 quantitative results from COMPASS and the Life Cycle Model (LCM) are based on a combination
18191 of hatchery and natural origin fish. This applies for both juvenile and adult results.

18192 Juvenile Fish Migration/Survival

18193 There are two structural measures in MO4 that may affect juvenile migration and survival.
18194 These are also in MO1 and are described in more detail there, but are summarized here:

- 18195 • **Construct additional powerhouse surface passage routes** at Lower Granite, Little Goose,
18196 Lower Monumental, Ice Harbor, McNary, and John Day Dams: This would route additional
18197 juvenile fish away from turbine passage routes to spillway or spillway-like routes, likely
18198 decreasing travel times and increasing survival. See MO1 Common Effects for details. As
18199 discussed in MO1, even with the most optimistic 30 percent passage efficiency assumption
18200 in place, the effect of these powerhouse surface passage structures on in-river survival and
18201 subsequent adult returns was minor. This is especially relevant in MO4, which employs spill
18202 up to the 125 percent TDG cap at all eight fish passage dams. These structures could
18203 potentially be more effective at influencing population level dynamics at lower spill levels
18204 than those included in MO4, but powerhouse passage is estimated to be so low under 125
18205 percent spill levels there were not enough fish passing via the powerhouse to have a
18206 meaningful impact.
- 18207 • **Install IFP turbines at John Day Dam** would improve juvenile survival of the juveniles that
18208 pass through this turbine route. See MO1 Common Effects for details.

18209 Additionally, MO4 includes a measure that was designed to improve overwintering adult
18210 steelhead and kelt survival but may also improve juvenile migration.

- 18211 • **Adding spillway weir notch gate inserts** at Lower Granite, Little Goose, Lower Monumental,
18212 Ice Harbor, McNary, and John Day Dams would allow the attraction of smolts and
18213 overwintering steelhead later into the season, and would allow the attraction using one
18214 fourth of the water. An increase in the total number of fish passing via surface routes is
18215 expected. See adult survival and migration section below for more details about this
18216 measure.

18217 Several operational measures warrant discussion here individually, regarding effects to juvenile
18218 fish. Measures that would result in changes to spill, flows, passage routes, or temperatures
18219 were incorporated into the fish models. Others could not be incorporated into modeling for
18220 effects analysis, or are modeled but may be difficult to separate from other factors; effects of
18221 these measures are discussed qualitatively.

- 18222 • MO4's spill to 125 percent TDG increases the proportion of spill at each of the lower
18223 Columbia and lower Snake projects compared to the No Action Alternative. The higher spill
18224 has the net effect of routing greater numbers of juvenile salmon and steelhead into spill
18225 routes and fewer through powerhouse routes such as the juvenile fish bypasses and turbine
18226 routes. For juvenile salmon and steelhead, quantitative fish modeling was used when
18227 available to estimate the effects of these spill changes on fish.
- 18228 • Drawing down the lower Columbia River projects to at, or near, MOP elevations will reduce
18229 water travel time to some degree relative to the No Action Alternative. At the same time,

- 18230 these drawdowns in the John Day pool would expose additional nesting habitat on Blalock
18231 Island and likely increase the risk of avian predation in this area for all species.
- 18232 • Holding contingency reserves within juvenile fish passage spill is likely to have little effect
18233 on juvenile migration. These measures were both included in the 80-year modeling
18234 datasets.
 - 18235 • The McNary Dam flow target measure is intended to provide additional spring flow
18236 augmentation in dry years to improve juvenile outmigration. More water in the Columbia
18237 River in dry years could increase survival of outmigrating juveniles by reducing in-river travel
18238 times. The effects of this measure were estimated by the primary fish models.
 - 18239 • Several measures in MO4 affect juvenile fish transportation rates and effects of these
18240 changes differ by ESU/DPS. Overall, the higher spill in MO4 decreases the proportion of
18241 juvenile salmon and steelhead available for transport. In addition, juvenile transport would
18242 be suspended from June 15 to August 15, when it would be re-initiated and extended until
18243 November 15 at the three lower Snake collector dams.
 - 18244 • Operating turbines above 1 percent peak efficiency could affect juvenile Snake River spring-
18245 run/summer-run Chinook direct survival. This measure is also in MO2 and MO3; see those
18246 alternatives for more details.
- 18247 The full suite of operational measures would change flow patterns in the Lower Columbia River
18248 with decreases in monthly average flows of 1 to 3 percent from April to June and a decrease of
18249 2 to 4 percent in month average flow in August. In the driest years, monthly average flows in
18250 May would be 12 percent higher than the No Action Alternative. Similar to the spill changes,
18251 fish modeling was used when available to estimate the effects of these flow changes on juvenile
18252 fish.
- 18253 Overall, MO4 is distinct compared to the No Action Alternative from a TDG perspective. There is
18254 substantially higher spill during the March-August period that generates higher and more
18255 prolonged elevated TDG relative to the No Action Alternative. UW/CBR TDG modeling, separate
18256 from COMPASS and CSS in-river survival estimates, estimated higher reach average exposure to
18257 TDG indices.
- 18258 There may be decreases in fish injury under MO4 with the lower number of powerhouse
18259 passages relative to the No Action Alternative and further reduced to some degree by
18260 installation of improved fish passage turbines at John Day Dam. Turbidity is not anticipated to
18261 change under MO4 relative to the No Action Alternative, as forebay drawdowns to near
18262 minimum operating pool elevations in the lower Columbia may temporarily have minor total
18263 suspended solids/turbidity effects, but they are expected to be minor given the size of large
18264 reservoirs. There may be an overall decrease in juvenile fish predation exposure under MO4
18265 due to these factors relative to the No Action Alternative, but the magnitude is uncertain. In
18266 some reservoirs, predation rates could potentially increase if poor tailraces conditions (e.g.
18267 eddies or other confusing flow patterns) are created by high spill levels. Changes in operations
18268 of Grand Coulee Dam under MO4 could increase entrainment of northern pike, hastening the

18269 invasion of this predator downstream where salmon and steelhead are found, thus increasing
18270 their predation exposure.

18271 Adult Fish Migration/Survival

18272 There are several operational and structural measures in MO4 that may affect adult salmon and
18273 steelhead. Two of these structures are in MO1 so are described in detail there and summarized
18274 here:

- 18275 • **Improve adult ladder passage** through modification of adult fish trap at Lower Granite Dam
18276 would reduce delays in migration through Lower Granite Dam.
- 18277 • **Installing pumping systems** to provide deeper, cooler water if available in adult fish ladders
18278 at Lower Monumental and Ice Harbor dams would decrease the temperature differential in
18279 fish ladders that can delay adult migration when surface waters are warm.

18280 Additionally, MO4 includes a unique measure not in any other alternative, which was designed
18281 to improve overwintering steelhead and kelt survival:

- 18282 • **Add spillway weir notch gate inserts at Lower Granite, Little Goose, Lower Monumental,**
18283 **Ice Harbor, McNary, and John Day Dams.** During the late fall and early winter adult
18284 steelhead that have overshot their natal streams, may overwinter in mainstem habitats. In
18285 the spring, some steelhead that have spawned (kelts) are attempting to return to the ocean
18286 and often pass downstream of project dams on the Snake and Columbia rivers prior to
18287 juvenile spill operations. Historically, spill operations through spillway weirs and normal
18288 spillbays have ceased at this time of year and these fish have only turbine routes available
18289 for downstream passage. Water flows are at their lowest at this time of year and can be as
18290 low as 20 kcfs in the Snake River. Using this water for spillway weir operation can take a
18291 large portion of remaining water flows. Spillway weir notch gates use about one quarter the
18292 flow of normal weirs and allow the weir to continue operating at very low flows. However,
18293 additional design modifications to the existing weir may be required to avoid the potential
18294 for additional injuries from adult sized fish impacting the concrete chute of the spillway.

18295 Fallback rates and passage blockages/delays of adult salmon and steelhead may increase under
18296 MO4. Fallback has been associated with higher flow and higher spill levels at many dams (Boggs
18297 et al. 2004; Keefer et al. 2005). Increased travel time of adults between Lower Monumental and
18298 Lower Granite Dams caused by blocked or delayed adult passage has been consistently
18299 observed when Little Goose spill percentages are above 30 percent. It is important to note that
18300 regional managers attempt to use in-season adaptive management to identify and remedy any
18301 excessive fallback or delays in passage. The effect of TDG on adult salmon and steelhead was
18302 not modeled for MO4, but an increase in reach average exposure to TDG is anticipated relative
18303 to the No Action Alternative.

18304 Temperatures in the lower Snake River and the lower Columbia River would be similar to the
18305 No Action Alternative. In the Columbia River, a general analysis indicated the overall number of
18306 days water temperatures in the McNary tailrace that exceed 20°C would not change relative to

18307 the No Action Alternative. A site- and timing-specific analysis of water temperature model
18308 results indicates slightly warmer conditions in July of low water years, when temperatures
18309 would be most stressful to fish. At McNary Dam, outflow temperature would exceed 20°C in 57
18310 days of low flow, high temperature year types (years like 2015), compared to 22 days in the No
18311 Action Alternative. Furthermore, the number of days that adult ladder temperature
18312 differentials exceed 2 degrees Celsius would slightly increase from 2.8 percent (No Action
18313 Alternative) to 3.8 percent (MO4), which may slightly increase delay in dam passage for adult
18314 fish (Caudill et al. 2013).

18315 In the balance between survival benefits of transporting juvenile fish with increasing the speed
18316 and survival of in-river fish, MO4 is expected to result in less transport and increased numbers
18317 of juveniles migrating in-river. This has the potential to shift the overall benefits to abundance
18318 of returning salmon and steelhead. This would depend on the degree to which decreased latent
18319 mortality would improve ocean survival of in-river fish. Based on the timing of when
18320 transported smolts reach the ocean compared to their in-river counterparts, NWFSC modeling
18321 predicts increased ocean survival for earlier arriving fish. Since more smolts would travel in-
18322 river and arrive below Bonneville Dam later compared to the No Action Alternative, the NMFS
18323 COMPASS and LCM models show generally lower abundances of returning Snake River adults
18324 without adding any factor for latent mortality. Adult returns to the Snake River are predicted by
18325 the NMFS models to be lower for spring migrating stocks unless ocean survival can be increased
18326 by 10 percent or more (i.e. a 10 percent or greater reduction in latent mortality). In contrast,
18327 CSS modeling predicts increased survival of juvenile salmon and steelhead moving downstream,
18328 as well as increased ocean survival, and therefore more returning adults. If CSS model
18329 predictions are accurate, SARs and adult abundance would be higher than the No Action
18330 Alternative. See the “Comparison of COMPASS and CSS Models” discussion in section 3.5.3.1 for
18331 more detail on the two models.

18332 ***Upper Columbia River Salmon and Steelhead***

18333 Upstream of McNary Dam, upper Columbia salmon and steelhead migrate past as many as five
18334 non-federal dams and reservoirs, which also impact the survival and passage of these species.
18335 The federal agencies do not dictate generation or spill levels at the PUD projects so metrics
18336 such as powerhouse encounter rate are not directly affected but are influenced by river flow
18337 levels coming through the upper Basin. The timing and volume of flow levels affected by CRS
18338 operational decisions are reflected in model analysis. COMPASS and LCM estimates of
18339 powerhouse encounter rate and SARs include passage effects from a combination of federal
18340 and PUD dam passage (Rock Island Dam to Bonneville Dam). CSS model results are not available
18341 for upper Columbia stocks.

18342 Upper Columbia Spring-Run Chinook Salmon

18343 *Summary of Key Effects*

18344 Structural and operational measures in MO4 are expected to increase juvenile survival of upper
18345 Columbia River spring-run Chinook salmon by 1.5 percent. Travel time and powerhouse

18346 encounters would be decreased, but increased exposure to TDG could offset some of the
18347 survival improvement. Adult upstream migrants could see additional delays and increased
18348 fallback with higher spill as well as increased TDG levels. Life cycle modeling indicated about a
18349 three percent increase in abundance. Increases could be higher if lower powerhouse
18350 encounters were to decrease delayed mortality in the ocean.

18351 *Juvenile Fish Migration/Survival*

18352 Juveniles in this ESU migrate through the Columbia River downstream past the four lower CRS
18353 projects in addition to up to five non-federal dams. Structural and operational measures
18354 described in the Common Effects section that describe changes from the No Action Alternative
18355 at McNary, John Day, The Dalles, and Bonneville Projects would apply to these fish. Based on
18356 the combination of structural improvements, higher spill, and reservoir drawdowns, COMPASS
18357 modeling estimates that MO4 is expected to result in a 1.5 percent increase in average juvenile
18358 survival for upper Columbia River spring-run Chinook salmon. Relative to the No Action
18359 Alternative, a 13 percent decrease in average juvenile travel time from McNary to Bonneville
18360 Dam, and a 23 percent decrease in the number of powerhouse passage events from Rock Island
18361 to Bonneville Dam (includes passage past three non-federal dams). TDG exposure would be
18362 higher for upper Columbia River spring-run Chinook salmon with reach average exposure nearly
18363 120 percent TDG. Increased mortality due to TDG could offset some of the increase in overall
18364 juvenile survival from operations and configurations under MO4. CSS cohort modeling for upper
18365 Columbia River spring-run Chinook was not available for this ESU. Table 3-92 displays a
18366 summary of these model metrics.

18367 Proposed MOP operations at projects would reduce pool elevations and increase nesting
18368 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these
18369 predators would likely increase predation on juvenile Chinook and reduce survival of these fish.
18370 The mean water temperature is expected to be the same as the No Action Alternative and
18371 would therefore have no difference in the risk of predation from other fish

18372 **Table 3-92. Multiple Objective Alternative 4 Juvenile Model Metrics for Upper Columbia River**
18373 **Spring-Run Chinook Salmon**

Metric (Model)	NAA	MO4	Change from NAA	% Change
Juvenile Survival (COMPASS) (McNary to Bonneville)	69.5%	71.0%	+1.5%	+2%
Juvenile Travel Time (COMPASS) (McNary to Bonneville)	6.1 days	5.3 days	-0.8 days	-13%
% Transported	No upper Columbia River spring-run Chinook transported			
Powerhouse Passages (COMPASS) (Rock Island to Bonneville)	3.29	2.53	-0.76	-23%
TDG Average Exposure (McNary to Bonneville)	115.9% TDG	119.3% TDG	3.6% TDG	3%

18374 *Adult Fish Migration/Survival*

18375 Neither of the adult structural measures in MO4 would provide benefits to upper Columbia
18376 River spring-run Chinook salmon because they are both in the Snake River basin. Increased spill
18377 and higher TDG in the lower Columbia River would likely reduce adult migration success to
18378 some extent.

18379 NWFSC LCM results predict abundance of the Wenatchee population, indicative of this ESU,
18380 would increase about 3 percent, assuming latent mortality was the same as in the No Action
18381 Alternative. CSS modeling was not available for this population, but the methods in CSS
18382 modeling suggest that fewer powerhouse encounters would reduce latent mortality and can be
18383 considered here. If the 23 percent lower powerhouse encounter rate were to reduce latent
18384 mortality and subsequently increase ocean survival, abundance could increase by more than 3
18385 percent. See Table 3-93 for details.

18386 **Table 3-93. Model Metrics Related to Adult Survival and Abundance of Upper Columbia River**
18387 **Spring-Run Chinook Salmon under Multiple Objective Alternative 4**

Metric (Model)	NAA	MO4	Change from NAA	% Change
SARs (NWFSC LCM) Rock Island to Bonneville	0.94%	0.96%	+0.02%	+2%
Abundance of Wenatchee population, representative of the upper Columbia River Spring Chinook salmon ESU (NWFSC LCM) ¹	498	513 (0%)	+15 (0%)	+3% (0%)
		673 (10%)	+175(10%)	+35% (10%)
		901 (25%)	+403 (25%)	+81% (25%)
		1308 (50%)	+810 (50%)	+163% (50%)

18388 ¹ NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARS or abundance output. For
18389 discussion purposes, potential increases in ocean survival of 10 percent, 25 percent, and 50 percent are shown.
18390 The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent
18391 scenarios of what SARs, or abundance hypothetically could be under the increased ocean survival if changes in the
18392 alternative were to decrease latent mortality by that much.

18393 Upper Columbia River Steelhead

18394 *Summary of Key Effects*

18395 Measures in MO4 may result in a negligible increase in average juvenile survival for upper
18396 Columbia River steelhead, no change in average juvenile travel time, and a 15 percent decrease
18397 in the number of powerhouse passage events from McNary to Bonneville Dam. Exposure to
18398 TDG would be higher than the No Action Alternative. Similar numbers and arrival timing of
18399 juveniles to the ocean, coupled with increased survival of upstream migrants, would likely
18400 result in similar abundances of returning adults. If latent mortality in the ocean were to
18401 decrease due to fewer powerhouse encounters, there could be a higher increase in abundance.

18402 *Juvenile Fish Migration/Survival*

18403 Juveniles from this DPS migrate through the Columbia River downstream past the four lower
18404 CRS projects in addition to up to five PUD dams. Operations at upstream reservoirs that affect
18405 seasonal flow patterns downstream influence travel time and survival at the PUD owned

18406 projects. Structural and operational measures described in the Common Effects section,
18407 including Additional Powerhouse Surface Passage at McNary and John Day and increased spill,
18408 would route more fish away from powerhouse routes and likely increase survival. COMPASS
18409 modeling estimates predict that from McNary Dam to Bonneville Dam, juvenile survival would
18410 increase by 0.3 percent and that travel time would be the same as the No Action Alternative.
18411 Powerhouse passages from Rock Island to Bonneville would decrease 15 percent, but TDG
18412 exposure would be increased to nearly 120 percent average exposure throughout juvenile
18413 migration. Table 3-94 summarizes juvenile model metrics for MO4.

18414 Proposed MOP operations at projects would reduce pool elevations and increase nesting
18415 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Steelhead are
18416 particularly susceptible to predation by Caspian terns. Increases in these predators would likely
18417 increase predation on juvenile steelhead and reduce survival of these fish. The mean water
18418 temperature is expected to be the same as the No Action Alternative and would therefore have
18419 no difference in the risk of predation from other fish.

18420 **Table 3-94. Multiple Objective Alternative 4 Juvenile Model Metrics for Upper Columbia River**
18421 **Steelhead**

Metric (Model)	NAA	MO4	Change from NAA	% Change
Juvenile Survival (COMPASS) (McNary to Bonneville)	65.8%	66.1%	+0.3%	+0%
Juvenile Travel Time (COMPASS) (McNary to Bonneville)	6.6 days	6.6 days	0 days	0%
% Transported (COMPASS)	No transport of upper Columbia steelhead			
Powerhouse Passages (COMPASS) (Rock Island to Bonneville)	2.72	2.31	-0.41	-15%
TDG Average Exposure (TDG Tool) (McNary to Bonneville)	116% TDG	119.6% TDG	+3.6% TDG	3%

18422 *Adult Fish Migration/Survival*

18423 Steelhead that go past their natal (birth) stream typically move downstream in October through
18424 March before the start of spring spill, while steelhead kelts move downstream throughout
18425 spring, both before and after the start of spill. Adults passing downstream after the start of spill
18426 are expected to have a slightly decreased rate of powerhouse passage events. In an adult
18427 passage study at McNary Dam, survival rates through turbines at McNary Dam averaged 90.7
18428 percent while survival through the spillway weir averaged 97.7 percent (Normandeau 2014).
18429 Steelhead are typically surface oriented and when a surface weir is available, a large fraction of
18430 adult migrants use the route (Ham et al. 2012).

18431 Life cycle abundance modeling was not available for upper Columbia River steelhead. However,
18432 insights from both the CSS and NWFSC LCM models can be considered when evaluating
18433 potential affects to abundance. The NWFSC LCM relies heavily on date of arrival below
18434 Bonneville Dam to estimate ocean survival and does not initially consider any increases or
18435 decreases in latent mortality. Based on COMPASS modeling, travel time and juvenile survival

18436 would be similar to the No Action Alternative, meaning a similar number of juveniles would
18437 arrive at the ocean with timing similar to the No Action Alternative. Because arrival timing
18438 would be similar, adult abundance could also be similar to the No Action Alternative.

18439 Haeseker et al. (2018) evaluated natural origin steelhead populations from the Entiat and
18440 Methow using CSS Snake River steelhead relationships, based on the CSS finding that upper
18441 Columbia River steelhead populations have similar responses to fresh water migration
18442 conditions (powerhouse passage experiences, flow) and marine conditions as their Snake River
18443 counterparts (DeHart 2019/CRSO-47). While their analysis did not model all the MO4 measures,
18444 spill to 125 percent TDG at the four lower Columbia projects was estimated to produce a 3.7
18445 percent SAR for the Entiat/Methow steelhead (personal communication, DeHart 2019). The
18446 increased SAR was a 28 percent increase relative to the baseline condition⁵ used by CSS
18447 modelers (Haeseker et al. 2018; DeHart 2019/CRSO-47), which may be similar to the No Action
18448 Alternative. Presumably, this increase would be a result of decreased latent mortality in the
18449 ocean.

18450 Upper Columbia River Coho Salmon

18451 See Upper Columbia spring-run Chinook salmon analysis as a surrogate for juvenile Upper
18452 Columbia coho salmon and Upper Columbia fall Chinook salmon analysis as a surrogate for
18453 adult Upper Columbia coho salmon.

18454 *Summary of Key Effects*

18455 Juvenile upper Columbia River coho survival would be similar to upper Columbia River spring-
18456 run Chinook, with structural measures and spill increases potentially increasing juvenile
18457 survival. Conditions for upstream migrating adults would include similar thermal regime,
18458 though higher temperature differential in fish ladders could hamper migration success. Overall,
18459 increases in juvenile survival and potentially higher survival due to lower powerhouse
18460 encounters and shorter travel times may result in higher returns of adult upper Columbia River
18461 coho salmon.

18462 *Juvenile Fish Migration/Survival*

18463 See upper Columbia River juvenile spring Chinook MO4 analysis for surrogate information of
18464 juvenile upper Columbia River coho salmon.

18465 Proposed MOP operations at projects would reduce pool elevations and increase nesting
18466 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these
18467 predators would likely increase predation on juvenile coho and reduce survival of these fish.

⁵ A comparison of CRSO No Action Alternative and MO4 H&H datasets and the CSS modeling assumptions from the Haeseker et al. (2018) analysis has not been completed. Hydrology and operations modeling in the lower Columbia may not be consistent with the rest of the CRSO modeling analyses in MO4. Inputs to the models would need to be compared.

18468 The mean water temperature is expected to be the same as the No Action Alternative and
18469 would therefore have no difference in the risk of predation from other fish

18470 *Adult Fish Migration/Survival*

18471 Adult migration conditions would be similar to upper Columbia River Fall Chinook salmon,
18472 which were analyzed in a workshop using water quality and hydrology outputs. MO4 water
18473 quality modeling showed no change in the frequency of water temperatures exceeding 20°C
18474 relative to the No Action Alternative, when adult upper Columbia coho salmon would be
18475 migrating upstream. Upper Columbia River coho adults migrate August/September (early run)
18476 and October/November (late run). McNary Dam outflows would be 5 to 10 percent lower than
18477 the No Action Alternative in September and October. See upper Columbia River Fall Chinook for
18478 surrogate information of adult upper Columbia coho salmon.

18479 Upper Columbia River Sockeye Salmon

18480 Refer to the upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia
18481 River sockeye salmon.

18482 *Summary of Key Effects*

18483 The changes with the greatest effect in MO4 would be the increase in TDG and minor increases
18484 in water temperature on dry years when augmentation flows are depleted. Both of these
18485 changes would have adverse effects on adult upstream migrating fish survival.

18486 *Juvenile Migration/Survival*

18487 Operational changes for MO4, would increase the number of days with TDG over 120 and 125
18488 percent at Bonneville and McNary dams, but no difference at Chief Joseph Dam. This change is
18489 substantial enough that MO4 could have greater adverse effects from TDG compared to the No
18490 Action Alternative. Refer to the upper Columbia River Chinook salmon analysis, as a surrogate
18491 for Upper Columbia River sockeye salmon juvenile and adult fish migration and survival metrics.

18492 Table 3-95 shows the comparison between MO4 and the No Action Alternative of percent of
18493 days with TDG over 120 and 125 percent. These increases could cause an increase in occurrence
18494 of GBT for juveniles and adults.

18495 **Table 3-95. Percent of Days with TDG above 120 Percent and 125 Percent in the No Action**
18496 **Alternative and in Multiple Objective Alternative 4**

Project	NAA % of days above 120% TDG	MO4 % of days above 120% TDG	NAA % of days above 125% TDG	MO4 % of days above 125% TDG
Bonneville Dam	10.8	25.8	3.3	3.7
McNary Dam	6.8	13.3	2.1	3.0
Chief Joseph Dam	Less than 0.1	Less than 0.1	0.0	0.0

18497 Proposed MOP operations at projects would reduce pool elevations and increase nesting
18498 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these
18499 predators would likely increase predation on juvenile sockeye and reduce survival of these fish.
18500 The mean water temperature is expected to be the same as the No Action Alternative and
18501 would, therefore, have no difference in the risk of predation from other fish.

18502 *Adult Migration/Survival*

18503 Neither of the adult structural measures in MO4 would provide benefits to upper Columbia River
18504 sockeye salmon because they are both in the Snake River basin. Increased spill and higher TDG in
18505 the lower Columbia River would likely reduce adult migration and success to some extent. Refer
18506 to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia River
18507 sockeye salmon, for additional information in modeled adult fish migration and survival metrics.

18508 MO4 would result in increased temperatures in July of low-flow years from Chief Joseph Dam to
18509 McNary Dam. For upper Columbia River sockeye, a ten percent increase (25 to 35 percent) in
18510 the number of days over 18°C at Chief Joseph Dam was noted. This increase would induce
18511 thermal stress for upstream migrating adult sockeye. The water temperature at Chief Joseph
18512 Dam influences sockeye that use the nearby tributary of Okanogan River. Okanogan sockeye
18513 arrive at the confluence of the Okanogan River with the Columbia River when water
18514 temperatures are warmer than 21°C, and then hold in the mainstem Columbia River. From
18515 around July 1 until the end of August, sockeye hold in the mainstem of the Columbia River until
18516 they get a temperature break in the Okanogan River and are then able to move upstream
18517 toward their spawning areas. Earlier runs of fish are more successful. The experience of moving
18518 up through warm water in the Columbia River, then warm water at the confluence of the
18519 Okanogan River Confluence where they hold, means that the cumulative stress is likely to
18520 decrease adult fish survival and their gamete viability.

18521 Increased returns of adults would be expected at Bonneville Dam from the increased juvenile
18522 survival, which would result in more juveniles arriving to the ocean. Challenges to upstream
18523 migration and survival could decrease those gains to some extent, but life cycle modeling was
18524 not completed for sockeye salmon. Furthermore, MO4 could provide potential increases of
18525 upper Columbia River sockeye salmon abundance if lower powerhouse encounter rates were to
18526 increase ocean survival compared to the No Action Alternative.

18527 Upper Columbia summer/fall-run Chinook salmon

18528 *Summary of Key Effects*

18529 Overall, there may be a decrease in reservoir habitat supporting upper Columbia summer/fall-
18530 run Chinook salmon, but the magnitude of this decrease is uncertain. There may be slightly
18531 greater adult migration delay due to slightly higher incidence of adult ladder temperature
18532 differentials above 2°C.

18533 *Juvenile Fish Migration/Survival*

18534 No change is anticipated in McNary and John Day Reservoir plankton communities or juvenile
18535 rearing habitat below Bonneville Dam under MO4, relative to the No Action Alternative (see Section
18536 3.4, *Water Quality*, and the Resident Fish subsection of Section 3.5.2.5 for additional information).
18537 However, shoreline habitat in the John Day pool is expected to decrease relative to the No Action
18538 Alternative due to the drawdown measures. Overall, there may be a decrease in reservoir habitat
18539 supporting upper Columbia summer/fall-run Chinook, but the magnitude is uncertain.

18540 Proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for
18541 Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these predators would
18542 likely increase predation on juvenile Chinook and reduce survival of these fish. The mean water
18543 temperature is expected to be the same as the No Action Alternative and would therefore have no
18544 difference in the risk of predation from other fish

18545 *Adult Fish Migration/Survival*

18546 As described in common effects, water temperatures in the Columbia River from Chief Joseph
18547 to McNary Dam may be warmer than the No Action Alternative in hot, dry years, resulting in
18548 additional migration delay, fallback, or susceptibility to disease. The number of days that adult
18549 ladder temperature differentials exceed 2°C would slightly increase from 2.8 percent (No Action
18550 Alternative) to 3.8 percent (MO4), which may slightly increase delay in dam passage for adult
18551 fish (Caudill et al. 2013).

18552 Specific to Okanogan upper Columbia summer/fall-run Chinook, there is a slight increase in
18553 number of days the mainstem would be 20°C or higher at the confluence of the Okanogan River
18554 (1.1 percent), relative to the No Action Alternative (0 percent) when adults hold in the
18555 mainstem. This means that there may be a slight decrease anticipated in the ability of the
18556 Okanogan fish to hold in the mainstem until water temperatures in the Okanogan River are cool
18557 enough that adults can move up from the mainstem without having to migrate through water
18558 temperatures typically considered lethal for salmon and steelhead (Ashbrook et al. 2009).

18559 The frequency of meeting the Vernita Bar Agreement to protect the prolific fall-run Chinook
18560 spawning in and around the Hanford Reach of the Columbia River in Washington is not
18561 expected to change under any MOs relative to the No Action Alternative. Other operational
18562 changes under MOs are likewise not anticipated to affect upper Columbia summer/fall-run
18563 Chinook spawning from the tailrace of Chief Joseph Dam to Bonneville Dam in terms of changes
18564 in flows, water temperatures, or TDG generated under the MOs.

18565 ***Middle Columbia River Salmon and Steelhead***

18566 Middle Columbia River Chinook Salmon

18567 See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River
18568 Spring-Run Chinook Salmon.

18569 *Summary of Key Effects*

18570 Using the surrogate species of upper Columbia River spring-run Chinook salmon, MO4 may
18571 result in minor increases in middle Columbia River Chinook salmon average juvenile survival
18572 from the McNary Dam to the Bonneville Dam tailrace, reduce travel times, and decrease the
18573 average number of powerhouse passage events. Other effects of MO4 are similar to those
18574 generally seen across all salmonids, and are discussed in the *Effects Common Across Salmon*
18575 *and Steelhead* under Section 3.5.3.7.

18576 *Juvenile Fish Migration/Survival*

18577 Under MO4, CRS operational changes may result in increased survival, lower travel times, and
18578 decreased powerhouse passage events on juvenile middle Columbia River Chinook. See Upper
18579 Columbia River spring-run Chinook analysis as a surrogate for juvenile Middle Columbia River
18580 Spring-Run Chinook Salmon.

18581 Proposed MOP operations at projects would reduce pool elevations and increase nesting
18582 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these
18583 predators would likely increase predation on juvenile Chinook and reduce survival of these fish.
18584 The mean water temperature is expected to be the same as the No Action Alternative and
18585 would therefore have no difference in the risk of predation from other fish

18586 *Adult Fish Migration/Survival*

18587 Effects to middle Columbia River Chinook salmon would be similar to upper Columbia River
18588 spring-run Chinook salmon, except they would not experience the increased temperatures in
18589 the upper Columbia River reach between Chief Joseph Dam to McNary Dam. Water quality
18590 modeling indicated this temperature effect would be attenuated by the time the water would
18591 get to McNary Dam, where temperatures would be similar to the No Action Alternative.
18592 Increased juvenile survival and shorter travel times would likely result in better ocean survival
18593 and more returning adult fish. Further improvements could be realized if lower powerhouse
18594 encounter rates were to decrease ocean mortality even further. See Upper Columbia River
18595 spring-run Chinook analysis as a surrogate for adult migration and survival of Middle Columbia
18596 River Spring-Run Chinook Salmon.

18597 Middle Columbia River Steelhead

18598 Refer to Upper Columbia River steelhead analysis as a surrogate for Middle Columbia River
18599 steelhead.

18600 *Summary of Key Effects*

18601 Juvenile survival of middle Columbia River steelhead would increase slightly, though travel time
18602 would be similar to the No Action Alternative. Fewer powerhouse encounters would be
18603 expected for these fish. A notched spillway weir and higher spill considered in MO4 would

18604 increase kelt survival, but higher spill would decrease upstream migrant success. Overall, similar
18605 or higher returns of middle Columbia River steelhead would be expected.

18606 *Juvenile Fish Migration/Survival*

18607 Under MO4, CRS operational changes would result in minor increases in juvenile survival,
18608 negligible reductions in travel times, and decreased powerhouse passage events on middle
18609 Columbia River steelhead. Powerhouse encounters would likely be lower due to increased spill
18610 and other measures, as described in Common Effects. Refer to Upper Columbia River steelhead
18611 analysis as a surrogate for Middle Columbia River steelhead.

18612 Proposed MOP operations at projects would reduce pool elevations and increase nesting
18613 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Steelhead are
18614 particularly susceptible to predation by Caspian terns. Increases in these predators would likely
18615 increase predation on juvenile steelhead and reduce survival of these fish. The mean water
18616 temperature is expected to be the same as the No Action Alternative and would therefore have
18617 no difference in the risk of predation from other fish

18618 *Adult Fish Migration/Survival*

18619 The addition of a notched spillway weir at McNary Dam with 2 kcfs of spill in October and
18620 November should increase survival of steelhead for the portion that pass McNary Dam and
18621 fallback in the fall. See the common effects section for more details. Increased spill would
18622 increase survival of kelts in the spring as well, but may increase straying and fallback of
18623 upstream migrants. Refer to Upper Columbia River steelhead analysis as a surrogate for Middle
18624 Columbia River steelhead for additional information.

18625 Life cycle abundance modeling was not available for steelhead. However, insights from both the
18626 CSS and NWFSC LCM models can be considered in discussing abundance, as described for upper
18627 Columbia River steelhead.

18628 ***Snake River Salmon and Steelhead***

18629 Snake River Spring/Summer-Run Chinook Salmon

18630 *Summary of Key Effects*

18631 The COMPASS and CSS modeling results predict that compared to the No Action Alternative,
18632 juvenile survival rates associated with MO4 from the lower Snake River to below Bonneville
18633 Dam would increase, though the magnitudes varied from less than one percentage point to
18634 almost 6 percent, depending on the model. Relative to the No Action Alternative, travel time
18635 would decrease between eight to 14 percent. The most notable changes would be about an 80
18636 percent relative reduction in powerhouse encounter rates, a major reduction in proportion of
18637 fish transported, and TDG exposure of almost 120 percent average through a smolt's migration.

18638 Adult passage impacts such as fallback or passage delays like those observed at Little Goose
18639 dam at spill levels greater than 30 percent could increase under MO4. Adults migrating
18640 upstream would also experience substantially elevated average TDG levels compared to the No
18641 Action Alternative.

18642 The resulting predicted change in SARS and abundance depends on model assumptions and
18643 drivers. The two models used in this analysis predict significantly different smolt-to-adult return
18644 rates in the absence of latent mortality. NWFSC LCM predicted a decrease in SARS and
18645 abundance if latent mortality was the same as in the No Action Alternative. If decreased
18646 powerhouse encounters were to decrease latent mortality by more than 10 percent and
18647 therefore increase ocean survival, the SARS and abundance would show an increase. CSS
18648 predicts major increases in both SARS and abundance. The two models also predict significantly
18649 different smolt-to-adult return rates.

18650 *Juvenile Fish Migration/Survival*

18651 This ESU migrates through the Snake and Columbia Rivers downstream past the eight CRS
18652 projects, four on the Snake River, and four on the lower Columbia River. Structural and
18653 operational measures described in the Common Effects section that describe changes at all of
18654 these dams would apply to these fish.

18655 MO4 would result in an increase in spill, a minor decrease in travel time; a reduction in the
18656 proportion of fish going through powerhouses at the projects, fewer juvenile Chinook salmon
18657 transported and increased juvenile in-river survival. Increased augmentation flows under MO4
18658 are expected to result in a slightly faster migration times for juvenile Chinook in low water
18659 years.

18660 For Snake River spring/summer-run Chinook salmon, the COMPASS model estimates that MO4
18661 would increase juvenile survival from Lower Granite dam to Bonneville Dam by less than one
18662 percent, and travel time would decrease by a day and a half (eight percent relative reduction).
18663 CSS modeling predicts a larger improvement, with survival 5.9 percent higher and travel time
18664 14 percent lower. However, high spill levels (especially during low river flow conditions) can
18665 create large and persistent eddies downstream of each dam. These eddies can adversely affect
18666 downstream travel time and in-river survival and are not accounted for in the models during
18667 low flow conditions. Consequently, to some degree both models may have the potential to
18668 overestimate improvements in juvenile survival, travel time, and SARs.

18669 Data suggests that juvenile Snake River Chinook salmon are migrating earlier in the season with
18670 some fish migrating as early as mid-March (DART 2020). Under MO4, spill would begin on
18671 March 1st to encompass these early migrants. However, current models are not calibrated to
18672 this early spill date and effects from early spill are as yet uncertain. Early spill could benefit
18673 early migrants by reducing migration delays and improving survival but river conditions in
18674 March can be very different than April and May (lower flows, cooler water temperature). The
18675 effects of spill may be much different in early spring compared to later.

18676 Both models predict that the combination of structural measures, increased spill, drawing down
18677 the lower Columbia River reservoirs to MOP, and additional flow augmentation in this
18678 alternative would be expected to decrease powerhouse encounters. The models predict a
18679 decrease in powerhouses encounters that range from 78 percent (COMPASS) to 84 percent
18680 (CSS) relative to the No Action Alternative. Spill levels in MO4 lead to increased exposure to
18681 TDG, which would increase from about 115 percent up to 120 percent average exposure to a
18682 smolt during outmigration. Both models also predict a substantial decrease in the number of
18683 smolts transported each year. These changes in TDG exposure and reduced transport could
18684 offset some of juvenile survival and life cycle benefits gained with higher spill.

18685 For Snake River spring/summer-run Chinook salmon, the COMPASS and CSS models estimate
18686 that MO4 would have the following effects compared to operations under the No Action
18687 Alternative, described below in Table 3-96.

18688 **Table 3-96. Multiple Objective Alternative 4 Juvenile Model Metrics for Snake River**
18689 **Spring/Summer-Run Chinook Salmon**

Metric (Model)	NAA	MO4	Change from NAA	% Change
Juvenile Survival (COMPASS)	50.4%	50.7%	+0.3%	+1%
Juvenile Survival (CSS)	57.6%	63.5%	+5.9%	+10%
Juvenile Travel Time (COMPASS)	17.7 days	16.2 days	-1.5 days	-8%
Juvenile Travel Time (CSS)	15.8 days	13.6 days	-2.2 days	-14%
% Transported (COMPASS)	38.5%	7.3%	-31.2%	-81%
% Transported (CSS)	19.2%	6.9%	-12.3%	-64%
Transport: In-River Benefit Ratio (CSS)	0.86	0.56	-0.30	-35%
Powerhouse Passages (COMPASS)	2.25	0.49	-1.76	-78%
Powerhouse Passages (CSS)	2.15	0.34	-1.81	-84%
TDG Average Exposure (TDG Tool)	115.1% TDG	119.7% TDG	+5.1% TDG	4%

18690 Several measures in MO4 affect juvenile Snake River spring/summer-run Chinook fish
18691 transportation rates. The higher spill in MO4 would substantially decrease the proportion of
18692 smolts transported during the spring spill season because fewer fish would be passing through
18693 the juvenile fish bypasses (a higher proportion would pass via spillways) and thus not available
18694 for transport. Juvenile fish transportation would be suspended on June 14 through August 15,
18695 then reinitiated and continued through November 15. Stopping transport in mid-June may
18696 affect the tail end of the Snake River spring/summer-run Chinook outmigration. Although there
18697 may be few fish still migrating downstream, late spring benefits from transportation are
18698 typically high, so this could lower juvenile migration success for those late migrating spring
18699 Chinook. The re-initiation of juvenile fish transportation after mid-August would occur after the
18700 Snake River spring/summer-run outmigration has ended and is not anticipated to affect this
18701 ESU. The life cycle implications of these juvenile experiences are discussed further in adult
18702 survival.

18703 The proposed MOP operations at projects would reduce pool elevations and increase nesting
18704 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in bird

18705 predators could increase predation on juvenile fall Chinook salmon and reduce survival of these
18706 fish. The mean water temperature is expected to be the same as the No Action Alternative and
18707 would therefore have no difference in the risk of predation from other fish.

18708 *Adult Fish Migration/Survival*

18709 Several structural measures in MO4 are anticipated to benefit adult Snake River
18710 spring/summer-run Chinook passage upstream and these include: modifying the adult trap and
18711 bypass loop at Lower Granite dam (reducing delay) and installing pumping systems at Ice Harbor
18712 and Lower Monumental ladders to reduce ladder temperature differentials if cool water is
18713 available in order to reduce delay.

18714 However, fallback rates, as well as passage delay or blockage, of Snake River spring/summer-
18715 run Chinook may increase under MO4. Fallback for this ESU has been associated with higher
18716 flow and higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). The fish that
18717 fell back were less likely to reach their spawning areas compared to fish that never fell back.
18718 When looking at PIT-tag data from Bonneville Dam during 2006–2011, a mean of 9.6 percent of
18719 spring/summer-run Chinook salmon that fell back reascended (NMFS 2019). Thus, the MO4
18720 higher spill operation would increase the fallback of Snake River spring/summer-run Chinook
18721 salmon adults as they migrate upstream.

18722 Adult passage delay and/or blockages may also increase under MO4. Substantial delays and
18723 decreases in adult passage rates at Little Goose have been frequently observed when spill levels
18724 exceed proportions greater than 30 percent of total river flow. This challenge could occur at
18725 other projects under the spill levels that would be implemented as part of MO4. Other
18726 operational effects discussed in common effects would also apply to this ESU. It is important to
18727 note that regional managers use in-season adaptive management to identify and remedy any
18728 excessive fallback or delay. Therefore, while the average survival for Snake River
18729 spring/summer-run Chinook salmon adults may decrease from the recent averages of about 89
18730 percent between Bonneville and McNary Dam, and 84 percent between Bonneville and Lower
18731 Granite Dam under the No Action Alternative, increased challenges with adult passage may or
18732 may not have a large effect under this alternative.

18733 Due to differing assumptions and drivers in the models, and possibly also due to the different
18734 populations modeled, the primary life cycle models produced widely differing results for Snake
18735 River spring/summer-run Chinook salmon SARS and abundance. The NWFSC LCM indicated a 12
18736 percent decrease in SARS and an average 32 percent decrease in abundance of adult returns to
18737 spawning grounds relative to the No Action Alternative. CSS, on the other hand, predicts MO4
18738 would increase SARS by 75 percent and nearly double the abundance of adult returns. These
18739 metrics are displayed in Table 3-97.

18740 **Table 3-97. Multiple Objective Alternative 4 Adult Model Metrics for Snake River**
18741 **Spring/Summer-Run Chinook Salmon**

Metric (Model)	NAA	MO4	Change from NAA	% Change
LGR-BON SARs (NWFSC LCM) ¹	0.88%	0.77% (0%)	-0.11% (0%)	-12% (0%)
		0.84% (10%)	-0.04% (10%)	-4% (10%)
		0.94% (25%)	+0.06% (25%)	+8% (25%)
		1.12% (50%)	+2.4% (50%)	+27% (50%)
LGR-BON SARs (CSS)	2.0%	3.5%	+1.5%	+75%
Abundance of south fork Salmon and middle fork salmon river representative populations (NWFSC LCM)	2,351	1,590 (0%)	-761 (0%)	-32% (0%)
		1,944 (10%)	-407 (10%)	-17% (10%)
		2,489 (25%)	+138 (25%)	+6% (25%)
		3,586 (50%)	+1,235 (50%)	+53% (50%)
Abundance (CSS) ²	6114	12159	+6045	+99%

18742 ¹ NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARS or abundance output. For
18743 discussion purposes, potential increases in ocean survival of 10 percent, 25 percent, and 50 percent are shown.
18744 The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent
18745 scenarios of what SARS, or abundance hypothetically could be under the increased ocean survival if changes in the
18746 alternative were to decrease latent mortality by that much.
18747 ² CSS provided results for six populations in the Grande Ronde/Imnaha Major Population Group. The absolute
18748 values represent those populations only; the percent change is considered indicative of the Snake River ESU for the
18749 purpose of comparing between MOs.

18750 The differences in model assumptions and the results returned can lend additional
18751 understanding to MO4 effects on Snake River spring/summer-run Chinook salmon, as well as
18752 infer understanding of other ESU/DPSs of salmon and steelhead as well.

18753 The CSS model predicts that in-river survival of juvenile spring Chinook salmon will increase
18754 above a threshold of roughly 60 percent, which is the point where the model predicts that
18755 transportation no longer provides a benefit compared to in-river migration. Because average
18756 survival is expected to be 63.5 percent, CSS results predict that reduced latent mortality more
18757 than offsets the reduction in the number of transported fish and therefore predicts major
18758 improvements in the abundance of returning Snake River spring Chinook salmon.

18759 The NMFS LCM uses input metrics from COMPASS results, such as juvenile survival and travel
18760 timing. The ocean survival of fish that survive to below Bonneville Dam are then estimated by a
18761 separate ocean model. The LCM model then uses an adult migration module based on adult fish
18762 returning from the ocean and have reached Bonneville Dam, and then computes expected
18763 survival for migration upstream to spawning grounds in the upper Snake River Basin.

18764 It is important to note that the juvenile survival indicated in the COMPASS metrics in the
18765 juvenile survival table applies to in-river traveling smolts only. Based on prior research,
18766 transported smolts are assumed to have a survival rate of 98 percent from Lower Granite to
18767 Bonneville Dam, compared to roughly 50 percent survival of in-river smolts. MO4 spill levels
18768 reduce the proportion of transported fish and increase the number of smolts experiencing the
18769 lower survival rate of the in-river travel. In-river migrants typically arrive below Bonneville Dam
18770 later than transported fish, which can decrease ocean survival in the model. The result would
18771 be fewer juveniles make it to the ocean under optimal timing resulting in lower overall survival

18772 to adulthood. There are also seasonal changes to the relative effect of transport each year.
18773 Generally-speaking, fish transported later in the spring season experience better SARs than in-
18774 river fish, while earlier in the season there is more benefit to in-river travel. This could be driven
18775 by challenges to in-river survival due to factors such as predation and thermal stress, which
18776 tend to increase from April to June. MO4 would cease transport in mid-June, when the survival
18777 benefit of being transported would be greatest. The lower rate of transported smolts could
18778 result in fewer adults straying to different populations than their origin.

18779 Another difference between the models is how ocean survival is accounted for. CSS models
18780 incorporate data that links increases or decrease in ocean survival to the hydrosystem
18781 experience of each smolt (i.e. latent or delayed mortality from CRS passage is expressed in
18782 changes to ocean survival). For MO4, ocean survival was predicted to increase from 3.6 percent
18783 under the No Action Alternative to 5.7 percent in MO2 (a 60 percent increase in ocean survival).
18784 Factors such as fewer powerhouse encounters and decreased travel time are assumed to
18785 increase survival in the ocean due to decreased latent mortality from a smolt's experience
18786 through the CRS projects, which would in turn increase the abundance of returning adults to
18787 the Columbia River.

18788 While ocean survival is not directly tied to the CRS passage experience in the NMFS LCM
18789 models, as a sensitivity analysis, factors of potential change in ocean survival were applied to
18790 the results. The model predicts an abundance increase under MO4 if ocean survival can be
18791 increased by more than 10 percent. The model run with increased ocean survival of 50 percent
18792 indicates an increase of 53 percent more adults than the No Action Alternative. However, the
18793 LCM model runs predict that if latent mortality is not reduced by more than 10 percent than
18794 the measures associated with MO4 would lead to a decrease in SARS for Snake River spring
18795 Chinook salmon and reduced adult abundance of the South Fork Salmon and Middle Fork
18796 Salmon River representative populations.

18797 Snake River Steelhead

18798 *Summary of Key Effects*

18799 Both models indicate moderate improvement to the juvenile metrics of survival, travel time,
18800 and powerhouse passage events, though the magnitude of estimated survival varies. The two
18801 models also predict significantly different smolt-to-adult return rates.

18802 *Juvenile Fish Migration/Survival*

18803 This ESU migrates through the Snake and Columbia Rivers downstream past the eight CRS
18804 projects, four on the Snake River, and four on the lower Columbia River. MO4 would result in a
18805 substantial increase in spill, a decrease in travel time, a reduction in the proportion of fish going
18806 through powerhouses at the projects and fewer juvenile steelhead transported. Increased
18807 augmentation of river flows under MO4 are expected to result in a slightly faster migration
18808 times for juvenile steelhead in low water years.

18809 Structural and operational measures described in the Common Effects section that describe
 18810 changes at all of these dams would apply to these fish. The combination of several measures is
 18811 predicted to decrease travel time and powerhouse encounters, as well as increase survival. This
 18812 includes a measure to increase Columbia River flows on dry years downstream of Chief Joseph
 18813 Dam. COMPASS modeling indicates 0.4 percent increase in average juvenile Snake River
 18814 steelhead survival; whereas CSS indicates the increase would be 16.6 percent, a major increase
 18815 in survival (30 percent improvement relative to the No Action Alternative). Both models agree
 18816 travel time would decrease by approximately a day and a half (8 percent (COMPASS) to 10
 18817 percent (CSS) reduction relative to the No Action Alternative). However, high spill levels
 18818 (especially during low river flow conditions) can create large and persistent eddies downstream
 18819 of each dam. These eddies can adversely affect downstream travel time and in-river survival
 18820 and are not accounted for in the models during low flow conditions. Consequently, both models
 18821 may overestimate improvements in juvenile survival, travel time, and SARs.

18822 There is evidence that juvenile Snake River steelhead are migrating earlier in the season with
 18823 some fish migrating as early as late March (DART 2020). Under MO4, spill would begin on
 18824 March 1st to encompass these early migrants. However, current models are not calibrated to
 18825 this early spill date and effects from early spill are as yet uncertain. Early spill could benefit
 18826 early migrants by reducing migration delays and improving survival but river conditions in
 18827 March can be very different than April and May (lower flows, cooler water temperature). The
 18828 effects of spill may be much different in early spring compared to later.

18829 The combination of structural measures, increased spill, drawing down the lower Columbia
 18830 River reservoirs to MOP, and additional flow augmentation in this alternative would be
 18831 expected to decrease powerhouse encounters. The models predict a decrease of 80 percent
 18832 (COMPASS) to 86 percent (CSS) relative to the No Action Alternative. While powerhouse
 18833 passage is expected to decrease, exposure to TDG would increase from about 115 percent up to
 18834 120 percent average exposure to a smolt during outmigration. This exposure could potentially
 18835 offset some of juvenile survival and life cycle benefits gained. The COMPASS model also
 18836 predicts a substantial decrease in the number of smolts transported each year. Table 3-98
 18837 displays the juvenile model metrics for Snake River steelhead under MO4.

18838 **Table 3-98. Multiple Objective Alternative 4 Juvenile Model Metrics for Snake River Steelhead**

Metric (Model)	NAA	MO4	Change from NAA	% Change
Juvenile Survival (COMPASS)	42.7%	43.1%	+0.4%	+1%
Juvenile Survival (CSS)	57.1%	73.7%	+16.6%	+30%
Juvenile Travel Time (COMPASS)	16.4 days	15.1 days	-1.3 days	-8%
Juvenile Travel Time (CSS)	16.2 days	14.6 days	-1.6 days	-10%
% Transported (COMPASS)	39.7%	7.2%	-32.5%	-82%
% Transported (CSS)	Not reported			
Transport: In River benefit ratio (CSS)	1.41	0.79	-0.62	-44%
Powerhouse Passages (COMPASS)	1.73	0.35	-1.38	-80%
Powerhouse Passages (CSS)	1.96	0.28	-1.68	-86%
TDG Average Exposure (TDG Tool)	115.4% TDG	119.8% TDG	+5.1% TDG	4%

18839 Several measures in MO4 would affect juvenile Snake River steelhead transportation rates.
18840 Juvenile fish transportation would be suspended on June 14. This may affect the tail end of the
18841 juvenile Snake River steelhead outmigration. Early season transport is most beneficial for
18842 steelhead, particularly for natural origin steelhead (Gosselin et al. 2018). Because over 95
18843 percent of the Snake River steelhead DPS has passed McNary Dam before mid-June (DART)
18844 reducing transport on June 14 should not decrease these benefits. The re-initiation of juvenile
18845 fish transportation from August 16 to November 15 would be after the juvenile Snake River
18846 steelhead outmigration and is not anticipated to affect this DPS.

18847 The higher spill in MO4 would substantially increase the number of juveniles passing via
18848 spillways and thus not able to be collected in juvenile fish bypasses for transport. COMPASS
18849 modeling predicts transportation would change from an average of 40 percent of the wild fish
18850 transported under the No Action Alternative to about 7 percent under MO4, an 82 percent
18851 relative decrease. The proportion transported in any given year could vary with hydrologic and
18852 operational conditions. Transported juvenile steelhead have an expected rate of 98 percent
18853 survival to below Bonneville Dam compared to the in-river juvenile survival of 43 percent.
18854 Because of this survival differential unless significant increases to in-river survival, similar to
18855 those predicted by the CSS model, fewer juveniles overall would survive the trip from Lower
18856 Granite to Bonneville Dam based on the COMPASS analysis. Further implications of transport
18857 are discussed in the Adult Survival section below.

18858 Proposed MOP operations at projects would reduce pool elevations and increase nesting
18859 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Steelhead are
18860 particularly susceptible to predation by Caspian terns. Increases in these predators would likely
18861 increase predation on juvenile steelhead and reduce survival of these fish. The mean water
18862 temperature is expected to be the same as the No Action Alternative and would therefore have
18863 no difference in the risk of predation from other fish.

18864 *Adult Fish Migration/Survival*

18865 Several structural measures in MO4 are anticipated to benefit adult Snake River steelhead
18866 passage upstream, including modifying the adult trap and bypass loop at Lower Granite Dam
18867 and installing pumping systems at Ice Harbor and Lower Monumental ladders intended to
18868 reduce ladder temperature differentials and migration delays. Other operational effects
18869 discussed in common effects would also apply to this ESU. Higher spring spill levels should
18870 result in higher survival rates for adult steelhead falling back through dams and kelts migrating
18871 downstream, as fewer adults used powerhouse passage routes when a spill route was available
18872 and overall downstream passage increased when surface passage was available (Normandeau
18873 et al. 2014). However, increases in fallback rates, adult passage delay and/or blockages may
18874 also increase under MO4 and are generally an adverse impact on adult survival and spawning
18875 success. Substantial delays and decreases in adult passage rates at Little Goose have been
18876 frequently observed when spill levels exceed proportions greater than 30 percent of total river
18877 flow. This challenge could occur at additional projects under the spill levels that are proposed
18878 as part of MO4.

18879 Based on CSS model results (see Table 3-99), major increases in adult returns would be
 18880 expected. For Snake River steelhead, the CSS cohort model predicted that the Lower Granite to
 18881 Bonneville Dam smolt to adult return rate would be 1.8 percent under the No Action
 18882 Alternative, and 3.1 percent under MO4. This represents a 72 percent increase in adult returns
 18883 back to Bonneville Dam per smolt passing Lower Granite Dam. This result assumes that fish
 18884 passage improvements at the CRS projects will reduce latent mortality affects and improve
 18885 ocean survival.

18886 **Table 3-99. Multiple Objective Alternative 4 Adult Model Metrics for Snake River Steelhead**

Metric (Model)	NAA	MO1	Change from NAA	% Change
SARs LGR-BON (CSS)	1.8%	3.1%	+1.3%	+72%

18887 There are no LCM results for Snake River steelhead but based on NMFS modeling results for
 18888 Snake River spring Chinook salmon, MO4 may actually result in a major decrease in adult
 18889 returns of Snake River steelhead compared to the No Action Alternative. As described in the
 18890 juvenile effects section, transportation rates would be much lower earlier.

18891 Typically, transportation provides a larger benefit to steelhead than spring Chinook. Because,
 18892 like with spring Chinook, both CSS and COMPASS models predict large declines in
 18893 transportation, it is reasonable to assume that LCM results would also show a decline in overall
 18894 SARs in the absence of any latent affects like those predicted by CSS modeling.

18895 Snake River Coho Salmon

18896 See Snake River spring/summer-run Chinook salmon as a surrogate for juvenile Snake River
 18897 coho salmon and Snake River fall-run Chinook as a surrogate for adult Snake River coho salmon.

18898 *Summary of Key Effects*

18899 Juvenile Snake River coho salmon survival may see a moderate increase in MO4, with faster
 18900 travel time, lower powerhouse encounters, but higher TDG exposure. The proportion of fish
 18901 transported would be lower than the No Action Alternative. Structural measures would
 18902 improve adult upstream migration. The overall abundance of returning adults is uncertain,
 18903 depending on how lower transport rates, higher in-river juvenile survival, and lower
 18904 powerhouse encounters interact with ocean survival.

18905 *Juvenile Fish Migration/Survival*

18906 MO4 would result in an increase in spill, a minor decrease in travel time, a reduction in the
 18907 proportion of fish going through powerhouses at the projects and fewer juvenile coho salmon
 18908 transported. Increased augmentation flows under MO4 are expected to result in a slightly
 18909 faster migration times for juvenile coho in low water years.

18910 Structural and operational measures described in the common effects section would apply to
 18911 juvenile Snake River salmon, and most of these would be expected to increase juvenile survival.

18912 Juvenile survival of Snake River coho salmon is estimated using juvenile modeling results for
18913 Snake River spring/summer-run Chinook salmon as a surrogate. See Snake River
18914 spring/summer-run Chinook salmon quantitative results as a surrogate for Snake River coho
18915 salmon.

18916 The proposed MOP operations at projects would reduce pool elevations and increase nesting
18917 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in bird
18918 predators could increase predation on juvenile fall Chinook salmon and reduce survival of these
18919 fish. The mean water temperature is expected to be the same as the No Action Alternative and
18920 would therefore have no difference in the risk of predation from other fish.

18921 *Adult Fish Migration/Survival*

18922 Structural measures in MO4 would reduce adult passage delays and increase adult Snake River
18923 coho salmon upstream migration success (e.g., modified adult trap and bypass loop at Lower
18924 Granite Dam, and pumping systems at Ice Harbor and Lower Monumental ladders to reduce
18925 ladder temperature differentials). Changes in fish spill would not affect upstream migration
18926 because they migrate after fish spill would end. See adult Snake River Chinook analysis as a
18927 surrogate for Snake River coho.

18928 Abundance of returning adults was not modeled for Snake River coho salmon, but some
18929 inferences can be made from life cycle modeling of Snake River spring/summer-run and fall-run
18930 Chinook salmon. In general, fewer coho salmon would be transported as juveniles in MO4, and
18931 more would travel in-river. Based on surrogate results, if decreased powerhouse encounters
18932 were to increase ocean survival, there could be a major increase in adults. If ocean survival
18933 would not be affected by changes in powerhouse encounters, then abundance could see a
18934 moderate decrease due to the overall later arrival of smolts to the ocean.

18935 Snake River Sockeye Salmon

18936 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake
18937 River sockeye salmon.

18938 *Summary of Key Effects*

18939 Notable effects of this alternative include increased nesting habitat for birds that puts
18940 outmigrating juvenile sockeye at greater risk of predation as well as greater TDG exposure. TDG
18941 exposure could be balanced somewhat by the faster travel time that may increase juvenile
18942 survival. A major beneficial effect for upstream migrating adults would occur due to much less
18943 transport of those fish as juveniles.

18944 *Juvenile Migration/Survival*

18945 MO4 would result in an increase in spill, a decrease in travel time, a reduction in the proportion
18946 of fish going through powerhouses at the projects and fewer juvenile sockeye salmon
18947 transported. Increased augmentation flows, under MO4, are expected to result in a slightly

18948 faster migration times for juvenile sockeye in low water years based on surrogate species,
18949 Snake River spring/summer-run Chinook salmon. Additional results for surrogate, juvenile
18950 Snake River spring/summer-run Chinook, showed that minor reductions in travel time would
18951 occur when compared to the No Action Alternative. Faster travel times generally result in
18952 increased survival rates.

18953 The proposed MOP operations at projects would reduce pool elevations and increase nesting
18954 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in bird
18955 predators could increase predation on juvenile sockeye salmon and reduce survival of these
18956 fish. The mean water temperature is expected to be the same as the No Action Alternative and
18957 would therefore have no difference in the risk of predation from other fish.

18958 Operational changes for MO4 would cause a major increase in the number of days with TDG
18959 over 120 and 125 percent at Bonneville, McNary, and Lower Granite projects. This change is
18960 substantial enough that MO4 could have greater adverse effects from TDG compared to the No
18961 Action Alternative. Table 3-100 shows the comparison between MO4 and the No Action
18962 Alternative of percent of days with TDG over 120 and 125 percent. This could cause an increase
18963 in occurrence of GBT for juveniles and adults.

18964 **Table 3-100. Percent of Days with TDG above 120 Percent and 125 Percent in the No Action**
18965 **Alternative and in Multiple Objective Alternative 4**

Project	NAA % of days above 120% TDG	MO4 % of days above 120% TDG	NAA % of days above 125% TDG	MO4 % of days above 125% TDG
Bonneville Dam	10.8	25.8	3.2	3.7
McNary Dam	6.8	13.3	2.1	3.0
Lower Granite Dam	2.7	22.6	1.3	12.9

18966 *Adult Migration/Survival*

18967 Under MO4, downstream transport of juvenile sockeye would be decreased; based on
18968 surrogate species, Snake River spring/summer-run Chinook salmon analyses expect major
18969 reduction in transportation. Decreased transportation could also result in an overall decrease in
18970 the amount of fallback and straying related to transport. Straying may still occur, but would be
18971 much closer to the natural levels for this population

18972 Adult sockeye migrate upriver in late summer and early fall when flows are low and water
18973 temperatures can be high. High spill levels under these conditions can cause migration delays as
18974 fish search for entrances to fish ladders. These delays are expected to occur at Little Goose Dam
18975 and may occur at other projects. This population travels far inland and adults have little excess
18976 energy reserves for migration. Delays for these fish may reduce fitness and the probability of
18977 successfully spawning.

18978 The summer water temperatures in the river during the upstream migration would not change.
18979 However, this alternative is estimated to have 58.9 percent of all days with a greater than 2-
18980 degree temperature difference between the river and the fish ladders compared to 50 percent

18981 of all days in the No Action Alternative. Having substantially more days with a greater than 2-
18982 degree temperature differential between river water and the fish ladders would cause a greater
18983 risk of delay at the dams. Installation of pumps to provide cool water in the ladders may reduce
18984 the number of days with large differentials in temperature.

18985 The increase in TDG could have adverse effects for adult migrating salmon. The other important
18986 water quality parameters of suspended sediment and DO would have no change compared to
18987 the No Action Alternative.

18988 Abundance of returning adults was not modeled, but some inferences can be made from life
18989 cycle modeling of surrogate Snake River spring/summer-run Chinook salmon. Fewer sockeye
18990 salmon would be transported as juveniles, and more smolts would travel in-river. Similar to the
18991 surrogate species, if decreased powerhouse encounters were to increase ocean survival, there
18992 could be a major increase in adults. If ocean survival would not be affected by changes in
18993 powerhouse encounters, then abundance changes are much harder to predict for this species.

18994 Snake River Fall-Run Chinook Salmon

18995 *Summary of Key Effects*

18996 The most notable effect of MO4 for Snake River fall-run Chinook would be the risk of delays for
18997 adults trying to migrate up the fish ladders. MO4 would have more days with a temperature
18998 differential of more than 2 degrees Celsius warmer water in the fish ladders. A minor beneficial
18999 effect for upstream migrating adults would be the reduction in straying that could occur
19000 because fewer fish would be transported as juveniles.

19001 *Larval Development/Juvenile Rearing*

19002 None of the measures under MO4 would change the substrate sizes or distribution in the
19003 spawning areas or expand suitable spawning areas; therefore, this alternative is expected to
19004 have the same larval development and juvenile rearing habitat conditions as the No Action
19005 Alternative. The same would be true for river depths in the spawning areas; no change is
19006 anticipated for eggs incubating in the gravel. Additionally, there would be no change in the
19007 reservoirs that provide rearing habitat for overwintering fall-run Chinook.

19008 *Juvenile Migration/Survival*

19009 MO4 would result in an increase in spill, a decrease in travel time, a reduction in the proportion
19010 of fish going through powerhouses at the projects and fewer juvenile fall Chinook salmon
19011 transported. Increased augmentation flows under MO4 are expected to result in negligible
19012 decreases in migration travel times for juvenile fall chinook in low water years.

19013 The proposed MOP operations at projects would reduce pool elevations and increase nesting
19014 habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in fish eating
19015 birds could increase predation on juvenile fall Chinook salmon and reduce survival of these fish.

- 19016 The mean water temperature is expected to be the same as the No Action Alternative and
19017 would therefore have no difference in the risk of predation from other fish.
- 19018 Turbidity effects in MO4 would have no expected change relative to the No Action Alternative
19019 in the Snake River, but would have effects in the McNary Dam tailrace because of forebay
19020 elevation manipulations at John Day Dam. The *Drawdown to MOP* measure may have minor
19021 turbidity effects, but effects are not expected to be great in large reservoirs.
- 19022 Some operations can produce hydraulic conditions within the tailrace that increase fish
19023 vulnerability to predation by extending the amount of time they spend in the tailrace. These
19024 conditions can also increase the time juvenile fish are exposed to elevated levels of dissolved
19025 gas. High spill under MO4 would likely create these conditions at Snake River dams. High spill
19026 levels can lead to large eddies and have been known to draw fish from spillway outflow into the
19027 slower flows of the powerhouse and circulate them in predator holding areas. These eddies can
19028 even pull fish from the bypass facilities into these predator rich areas. Under MO4, juvenile fish
19029 would experience an increased risk of predation because of these hydraulic conditions.
- 19030 The benefits of transport for fall Chinook increase in the summer and fall (Smith et al. 2018).
19031 Consequently, the termination of transport from July 1 through August 15 may potentially
19032 reduce juvenile survival and adult returns for this species and would require adaptive
19033 management.
- 19034 *Adult Migration/Survival*
- 19035 Under MO4, downstream transport of juvenile fish would be reduced compared to the No
19036 Action Alternative. Because stray rates of transported fish are approximately 5 percent greater
19037 than for fish left in river during migration (Bond et al. 2017), there would be a minor decrease
19038 in the numbers of fish that stray to other tributaries. Straying may still occur but would be
19039 reduced.
- 19040 River water temperatures during the upstream migration period are expected to be the same
19041 as in the No Action Alternative, which would mean the same rate of delay and fallback would
19042 continue to occur. Likewise, there would be no change to sediment concentrations or DO levels
19043 from any measures in MO4 during the adult migration period.
- 19044 The temperature differential between the river and the fish ladders would be worse than in the
19045 No Action Alternative. MO4 would have 58.6 percent of all days in August and September with
19046 more than 2 degree Celsius differential compared to 50.1 percent in the No Action Alternative.
19047 This would have a slight increase in risk of delay under MO4 due to approximately five more days
19048 with warmer water in the ladders. Installation of ladder cooling pumps at Lower Monumental
19049 and Ice Harbor dams would reduce number of days at these dams where temperatures
19050 differences between the river and fish ladders would deter migration.
- 19051 No life cycle modeling is available for Snake River Fall Chinook salmon, but some inferences can
19052 be made from life cycle modeling of Snake River Spring/Summer Chinook salmon. Fewer
19053 salmon would be transported as juveniles, and more would travel in-river. The relative SAR of

19054 transported fall Chinook is on average lower than that of in-river fish in June and early July,
19055 while the benefits of transportation on SAR are highest in August and September (Gosselin et
19056 al. 2018). Similar to Snake River spring/summer-run Chinook salmon, if decreased powerhouse
19057 encounters were to increase ocean survival, there could be a major increase in adults. If ocean
19058 survival would not be affected by changes in powerhouse encounters, then abundance could
19059 see a moderate decrease due to the overall later arrival of smolts to the ocean. Fewer fish in
19060 late transport would result in reduced adult returns.

19061 ***Lower Columbia River Salmon and Steelhead***

19062 Lower Columbia River Chinook Salmon

19063 Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower
19064 Columbia River Chinook salmon.

19065 *Summary of Key Effects*

19066 Juvenile Lower Columbia River Chinook salmon survival would be decreased slightly under MO4
19067 due to modeled conditions such as spill, and likely be further decreased due to exposure to high
19068 TDG during outmigration. Adult migration would likely be less successful with increased
19069 fallback, delays, and TDG effects.

19070 Results (and change from the No Action Alternative) for metrics for lower Columbia River
19071 Chinook salmon:

- 19072 • Negligible decrease in juvenile project survival at Bonneville Reservoir and Dam (see Snake
19073 River spring-run/summer-run Chinook used as a surrogate) = (-0.8 percent)
- 19074 • Bonneville Dam median outflows, April to June = (0 percent to -2 percent most years)
- 19075 • Bonneville Dam outflows, August to September = (-4 percent to -7 percent)
- 19076 • Spill, Bonneville = Spill, Bonneville Dam = March (+71 percent) April-Jul (+10 percent to +26
19077 percent)
- 19078 • Temperature, The Dalles Dam, days exceeding state standard = 72 days (+1 day)
- 19079 • Temperature, Bonneville Dam, days exceeding state standard = 57 days (-1 day)
- 19080 • TDG, The Dalles Dam, days exceeding state standard = 127 days (+94 days)
- 19081 • TDG, Bonneville Dam, days exceeding state standard = 113 days (+52 days)

19082 *Juvenile Fish Migration/Survival*

19083 Five of the 32 populations of Lower Columbia River Chinook salmon pass Bonneville Dam on
19084 their downstream outmigration to the ocean. Modeling was not available for this ESU so
19085 juvenile survival at Bonneville Dam of Snake River spring/summer-run Chinook salmon was
19086 used as a surrogate of juvenile survival. COMPASS modeling predicts juvenile survival of 88.2

19087 percent through the Bonneville Project, including the reservoir and the dam, or 0.8 percent
19088 lower than the No Action Alternative. It is important to note this model result does not
19089 incorporate any effects from TDG exposure, which would be much higher in MO4. The number
19090 of days that would exceed the state water quality standard for TDG at The Dalles and Bonneville
19091 tailwater would be 90 percent and 180 percent higher, respectively.

19092 Outflows can influence juvenile outmigration if changes in flows are enough to noticeably affect
19093 travel time, and therefore survival. Increased spill also decreases travel time. Hydrology
19094 modeling predicts spring-run and late-fall-run fish would experience outflows about 1 to 2
19095 percent lower in April through August than the No Action Alternative in most years, but flow
19096 augmentation in dry years could improve migration speed for the portion of all runs that
19097 outmigrate in May and June and sometimes July. Increased spill in April through July would also
19098 decrease travel time. Fall-run fish outmigrate in late summer and may see flows up to 4 to 7
19099 percent lower in August through September than the No Action Alternative, but with higher
19100 spill. This decrease in late summer flows could affect the ability of these juveniles to outmigrate
19101 and use habitats in the estuary. Water quality modeling indicated there would not be a
19102 perceptible change in temperature in the lower river with MO4 operations.

19103 *Adult Fish Migration/Survival*

19104 There are no structural measures in MO4 that would increase adult passage and survival.
19105 Fallback rates for spring-run would likely increase with higher spill in April under MO4 as
19106 fallback is associated with higher flow and higher spill levels at many dams (Boggs et al. 2004;
19107 Keefer et al. 2005). However, regional managers use in-season adaptive management to
19108 identify and remedy any excessive fallback. Hydrology and water quality modeling predicts
19109 flows and temperatures would be similar to the No Action Alternative, except for slightly lower
19110 fall flows could increase adult migration of fall-run and late-fall-run fish. Higher TDG described
19111 for juvenile fish would also affect adult migrating fish. Although TDG would be higher
19112 throughout spring and summer than the No Action Alternative, the biggest difference would be
19113 in March and April where TDG would typically be below the state standard in the No Action
19114 Alternative (about 112 percent in March) but over 120 percent TDG in MO4. This would
19115 increase TDG-related effects to spring-run adults.

19116 Lower Columbia River Steelhead

19117 Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

19118 *Summary of Key Effects*

19119 Juvenile Lower Columbia River steelhead survival would be decreased slightly due to modeled
19120 conditions such as spill and flows, as well as high TDG. In dry years, juvenile survival would be
19121 improved with additional flow augmentation. Adult upstream migration would likely be less
19122 successful with increased fallback, delays, and TDG effects; however, kelt survival would be
19123 improved with higher spill.

19124 *Juvenile Fish Migration/Survival*

19125 Survival would be decreased slightly due to modeled conditions such as spill, and likely be
19126 further decreased due to exposure to high TDG during rearing and outmigration.

19127 MO4 results (and change from the No Action Alternative) for metrics for Lower Columbia River
19128 Steelhead:

- 19129 • Negligible decrease in juvenile project survival, Bonneville Reservoir and Dam (Snake River
19130 steelhead used as a surrogate) = (-0.6 percent)
- 19131 • Bonneville Dam outflows, April to June = (0 percent to -2 percent most years.
- 19132 • Bonneville Dam outflows, August to October = (-4 percent to -7 percent) otherwise (+/- 0 to
19133 2 percent)
- 19134 • Spill, Bonneville Dam = March (+71 percent) April-Jul (+10 percent to +26 percent)
- 19135 • Temperature, The Dalles Dam, days exceeding state standard = 72 days (+1 day)
- 19136 • Temperature, Bonneville Dam, days exceeding state standard = 57 days (-1 day)
- 19137 • TDG, The Dalles Dam, days exceeding state standard = 127 days (+94 days)
- 19138 • TDG, Bonneville Dam, days exceeding state standard = 113 days (+52 days)

19139 Modeling juvenile survival of Snake River steelhead, used as a surrogate for the Lower Columbia
19140 River steelhead, through the Bonneville project (reservoir and dam), predicts under MO4
19141 negligible lower survival than the No Action Alternative. Among the fish that pass Bonneville
19142 Dam, higher spill in the spring would slightly decreased dam passage survival, although it would
19143 also reduce travel time and result in faster transitions through the project area. In dry years,
19144 additional flow augmentation would help move juveniles out more quickly than the No Action
19145 Alternative. Temperatures would be similar to the No Action Alternative. It is important to note
19146 this model result does not incorporate any effects from TDG exposure, which would be much
19147 higher in MO4. The number of days that would exceed the state water quality standard for TDG
19148 at The Dalles and Bonneville tailwater would be 90 percent and 180 percent higher,
19149 respectively. TDG would be higher than the water quality standard for most of the juvenile
19150 outmigration season.

19151 *Adult Fish Migration/Survival*

19152 There are no structural measures in MO4 for increased adult upstream passage. Under MO4,
19153 higher spill levels during upstream migration periods should result in higher survival rates for
19154 adult steelhead falling back through dams and kelts migrating downstream, but may increase
19155 fallback and delay of upstream migrants. Lower flows in August through October may increase
19156 the migration speed and success of the tail end of the summer run.

19157 Temperatures would be similar to the No Action Alternative, and adult fish would generally
19158 experience higher TDG as described for juveniles. Higher TDG described for juvenile fish would
19159 affect adult migrating fish as well. Although TDG would be higher throughout spring and
19160 summer than the No Action Alternative, the biggest difference would be in March and April

19161 where TDG would typically be below the state standard in the No Action Alternative (about 112
19162 percent in March) but over 120 percent TDG in MO4. This would increase TDG-related effects to
19163 the winter run. Summer steelhead would experience much higher TDG throughout their
19164 upstream migration period.

19165 Lower Columbia River Coho Salmon

19166 See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower
19167 Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult
19168 Lower Columbia River coho salmon.

19169 *Summary of Key Effects*

19170 Overall, a negligible decrease in juvenile passage survival for Lower Columbia River coho is
19171 expected due to increased spillway passage and water temperatures under MO4, relative to the
19172 No Action Alternative. An increase in fish ladder temperature differentials would also decrease
19173 adult migration success.

19174 *Juvenile Fish Migration/Survival*

19175 Lower Columbia River coho salmon passing Bonneville Dam under MO4, based upon project
19176 survival of Snake River spring/summer-run Chinook salmon as a surrogate, would result in
19177 negligible decreases in survival (approximately 0.9 percent). Refer to Snake River spring-run
19178 Chinook for surrogate information in Section 3.5.2.6. Generally speaking, higher spill at
19179 Bonneville Dam results may result in lower survival through the dam.

19180 *Adult Fish Migration/Survival*

19181 Lower Columbia River coho salmon adults are similar in upstream migration characteristics to
19182 Snake River fall-run Chinook salmon and were used as a surrogate for adult Lower Columbia
19183 River coho salmon. Snake River fall-run Chinook salmon were analyzed in workshops using
19184 modeled water quality and hydrology data; MO4 operational changes could result in fewer days
19185 when lower Columbia water temperatures in reservoirs would exceed 20°C, and water
19186 temperatures around Bonneville Dam specifically may be slightly cooler under all of the MOs
19187 compared to the No Action Alternative. However, MO4 analysis showed more days when lower
19188 Columbia fish ladder temperature differentials would exceed 2 degrees Celsius. This change in
19189 ladder temperature differentials may cause an increase in adult salmon to stop or delay
19190 migration relative to the No Action Alternative. For additional information on the surrogate
19191 species, Snake River fall-run Chinook, refer to Section 3.5.2.5.

19192 Columbia River Chum Salmon

19193 Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia
19194 River chum salmon.

19195 *Summary of Key Effects*

19196 MO4 operations would result in more difficulty in meeting chum flows downstream of
19197 Bonneville Dam, with an increase of 12 percent of years, compared to the No Action
19198 Alternative, where the flows could not be met without additional drafting of Grand Coulee.
19199 Juvenile outmigration could be slower due to decreased outflows in March, and the small
19200 proportion of juvenile chum salmon that pass Bonneville Dam would experience negligible
19201 increased survival at the dam. Adult migration and survival would likely be similar to the No
19202 Action Alternative.

19203 MO4 is expected to result in a 1 percent decrease in juvenile chum survival relative to the No
19204 Action Alternative from spawning sites directly downstream of Bonneville Dam, with the
19205 decision to either abandon chum or draft additional water from Grand Coulee in 20 percent of
19206 years. Incubating chum sac fry would be exposed to TDG above 105 percent in 30 out of 80
19207 years, which is higher than the modeled exposure rate in the No Action Alternative (four out of
19208 80 years).

19209 *Larval Development/Juvenile Rearing*

19210 How operations under MO4 affects the ability of Grand Coulee to provide winter flows to
19211 protect chum redds and provide sufficient access to habitat was calculated using hydrology
19212 modeling. Chum flows may also be impacted by changes to carryover at storage projects and
19213 how they impact inflows to Grand Coulee reservoir; the water supply measure will reduce
19214 carryover in all years, and the McNary Flow Objective measure will substantially reduce
19215 carryover in dry years. Under MO4, chum flows would be met in 80 percent of years, compared
19216 to 92 percent of years in the No Action Alternative. In years when additional releases from
19217 Grand Coulee for chum would be needed, the average additional volume needed would be 0.24
19218 Maf. This would be a moderate decrease to the success of chum rearing and decision-makers
19219 would have to decide whether to increase risk to chum eggs or reduce spring augmentation
19220 flows for spring migrating juvenile salmon.

19221 Maintaining water saturation of 105 percent TDG or less from November 1 through April
19222 30303030 appears to provide a sufficient level of protection to chum salmon eggs and sac fry
19223 incubating in the gravel downstream of Bonneville Dam in the Ives/Pierce Island Complex. In
19224 MO4, chum sac fry would be exposed to TDG above 105 percent in 30 out of the 80-year record
19225 modeled, all in the mid- to late April timeframe. This is 25 more years out of 80 (or 31 percent
19226 more often) than the No Action Alternative where this TDG threshold would be exceeded.

19227 *Juvenile Fish Migration/Survival*

19228 Chum salmon only encounter one CRS project, Bonneville Dam; therefore, none of the
19229 structural measures described in common effects would apply to these fish, and only a small
19230 proportion of spawning occurs above Bonneville Dam. As there is no direct estimate of
19231 Bonneville Project survival specific to juvenile chum, juvenile model metrics for Snake River
19232 spring/summer-run Chinook salmon are used as a surrogate to estimate any change in juvenile
19233 survival for the portion that pass Bonneville Dam. Under MO4, COMPASS modeling for the

19234 surrogate species indicates that CRS operational changes are expected to result in negligible
19235 decreases in juvenile passage survival compared to the No Action Alternative. MO4 would not
19236 change the outmigration conditions for juvenile chum that spawn below Bonneville Dam, other
19237 than they may experience higher TDG than under the No Action Alternative. Bonneville Dam
19238 outflows would be similar to the No Action Alternative when chum juveniles begin
19239 outmigration.

19240 *Adult Fish Migration/Survival*

19241 Most chum spawn downstream of Bonneville. Migration of chum into the Columbia River is in
19242 October and November. Bonneville Dam average monthly outflows would be about 1 to 3
19243 percent lower than the No Action Alternative and would be a negligible effect on adult
19244 migration under MO4.

19245 **Other Anadromous Fish**

19246 *Pacific Eulachon*

19247 Summary of Key Effects

19248 Eulachon would continue to migrate into the Columbia River from November through March,
19249 with specific dates of migration and spawning based on a variety of environmental factors
19250 including temperature, high tides, and ocean conditions (NMFS 2017). Temperature, spawning
19251 locations, and substrate would be the same as the No Action Alternative.

19252 In most water year types, MO4 would have little change in the time between the peak
19253 spawning runs, egg development, and larval emergence. In extremely dry years (the lowest 1
19254 percent), the freshet would begin a couple of days earlier, but would be sustained longer.
19255 During the driest 10 percent of years, the discharge duration would be sustained about 8
19256 percent to 9 percent higher in May and June, which could increase larval dispersal downstream
19257 in very low water years.

19258 Spring flows for juvenile outmigration would be a negligible change from the No Action
19259 Alternative in March and April, and a 10 percent increase in May in the driest 1 percent of years
19260 that would be a minor benefit to juvenile outmigration in those years. Higher flows are linked
19261 to higher predation rates on adults, but the minor increase in flows in extreme dry years would
19262 likely be a negligible effect on adult predation in those driest years.

19263 *Green Sturgeon*

19264 Summary of Key Effects

19265 The Columbia River use by green sturgeon is primarily foraging habitat for adults and subadults.
19266 Key effects of MO4 would be similar to the No Action Alternative in most years. Hydrology
19267 modeling indicated in dry years (lowest 25 percent of years) there may be a variation between
19268 the months of July when flows would be 4 percent higher than the No Action Alternative and
19269 August when flows would be 5 percent lower than the No Action Alternative. This change of

19270 flows (when flow augmentation would cease) could cause forage sources to move further
19271 upstream in July and then downstream in August, but sturgeon would likely be able to continue
19272 foraging effectively and this would be a negligible effect.

19273 ***Pacific Lamprey***

19274 Summary of Key Effects

19275 MO4 has several measures that are designed specifically to benefit lamprey. These measures
19276 are proposed structural improvements that would include converting extended-length
19277 submersible bar screens to submersible bar screens, expanding the network of Lamprey
19278 Passage Structures to bypass impediments in fish ladders, changing the design for turbine
19279 cooling water strainers, replacing turbines for safer fish passage, among other physical
19280 modifications to reduce fish injury and mortality.

19281 The most substantial benefit of MO4 would be the improvements to get fish to enter the fish
19282 ladders; this would occur through expanding the network of Lamprey Passage Structures and
19283 modifying fish ladders to incorporate lamprey passage criteria into the structural modifications.
19284 Adults migrating upstream in July would experience higher water temperatures in the Columbia
19285 River from Chief Joseph Dam to McNary Dam that would likely lower their survival and
19286 migration success.

19287 Larval Development/Juvenile Rearing

19288 Hydrosystem operations affect larval lamprey rearing in shallow waters due to elevation
19289 fluctuations that can dewater larvae rearing in sediment. Rates that lower the water level less
19290 than 10 cm per hour are natural, but faster than that can strand lamprey. In MO4, drawdowns
19291 in late March could dewater larval lamprey rearing in sediment. Most fine sediments at
19292 tributary junctions host lamprey. This alternative could reduce the amount of habitat available
19293 for larval lamprey (reference to be added prior to final). Although it is difficult to quantify, the
19294 effect is anticipated to be minor to moderate.

19295 As juveniles are rearing, temperature affects outmigration: juveniles move out of the system
19296 faster in warmer temperatures. This alternative would have no change in the Snake and Lower
19297 Columbia Rivers, but the middle Columbia reach would have minor increases in July during low
19298 flow years. It has not been quantified what influence this may have on number of lamprey or
19299 intensity of effect. If juveniles are triggered to migrate earlier compared to the No Action
19300 Alternative, they would likely be slightly smaller and therefore slightly less fit for the long
19301 journey down river.

19302 Juvenile Fish Migration/Survival

19303 A substantial amount of injuries and mortality can occur for outmigrating juveniles on their
19304 downstream migration including impingement on screens.

19305 These measures are also in MO1 and their effects are described in more detail in the lamprey
19306 section in that alternative. Briefly, the measures and their anticipated effects would be:

19307 Converting the extended-length submersible bar screens to submerged traveling screens would
19308 substantially reduce mortality due to impingement.

19309 • A new design of structure for exclusion of juvenile lamprey from cooling water strainer
19310 intakes would substantially reduce or eliminate this pathway of mortality.

19311 • Additional powerhouse surface passage would change the dynamics of lamprey passage. A
19312 higher percentage of lamprey would be expected to pass via the safer surface routes
19313 instead of the turbines in relation to the No Action Alternative.

19314 • Replacing turbines at John Day Project with a newer design of turbine would improve
19315 conditions for fish passage and reduce the injury rate for lamprey.

19316 • The hydraulic analysis shows an increased hydrograph in May/June in low water years,
19317 which could benefit lamprey from upper river areas as it could increase outmigration
19318 triggers and speed.

19319 • Reservoir drawdown to MOP to speed up outmigration travel time would benefit juvenile
19320 outmigrating lamprey.

19321 • American lamprey lack a swim bladder and are considered less susceptible to barotrauma
19322 than salmonids (Colotelo et al. 2012).

19323 Because of the high degree of uncertainty surrounding how many juvenile lamprey are lost or
19324 injured on their downstream migration, it is difficult to quantify the improvement represented
19325 by all of the measures. For fish that encounter multiple dams on their migration downstream,
19326 reducing the total number of hazards would increase their probability for survival to adult life
19327 stage.

19328 Adult Migration/Survival

19329 Similarly, there are measures in MO4 that were also in MO1 that improve adult lamprey
19330 passage; they are described and analyzed in detail in the lamprey section of MO1 and
19331 summarized here:

19332 • Expanding the network of lamprey passage structures would improve lamprey passage.

19333 • Modifying the upper ladder serpentine flow control ladder sections at Bonneville Dam
19334 would reduce migration delays caused by baffles in this section.

19335 • Adding cooler water in the fish ladders at Lower Monumental and Ice Harbor would be
19336 expected to benefit lamprey because this has been successful at Little Goose and Ice
19337 Harbor.

19338 • Modifications to Lower Monumental include diffuser grate plating. This modification has
19339 been completed at all other ladders in the CRS, except Lower Monumental, and has resulted
19340 in slight benefits to lamprey passage.

19341 • Johnson et al. (2012) found that lamprey passage is inhibited when ladder velocities are too
19342 high and when attraction flow to a lamprey entrance is hard to distinguish from nearby
19343 discharges such as spillway or turbines.

19344 The overall expected improvements in lamprey passage efficiency should decrease
19345 susceptibility to physical stress and mortality, and shorter holding time would be beneficial to
19346 the fish. These structural measures for lamprey are expected to provide a substantial benefit to
19347 the population size and distribution of Pacific lamprey in the Columbia Basin. Compared to the
19348 No Action Alternative, all proposed structural measures to reduce losses would have benefits to
19349 the population and recruitment to the next generation. The combined effect of all proposed
19350 structural modifications would be a substantial improvement for lamprey survival and fitness.

19351 A site- and timing-specific analysis of water temperatures indicates slightly warmer conditions
19352 in July of low water years, when temperatures would be most stressful. At McNary Dam,
19353 outflow temperature would exceed 20°C in 57 days of low flow, high temperature year types
19354 (similar to 2015), compared to 22 days in the No Action Alternative. This would result in lower
19355 migration success and survival of adult lamprey.

19356 ***American Shad***

19357 Summary of Key Effects

19358 No change is anticipated to plankton communities, but shoreline habitat is expected to
19359 decrease under MO4, so there may be a minor decrease in juvenile shad. The proportion of
19360 shad moving upstream of McNary Dam in low flow years may increase under MO4, so an
19361 overall decrease in shad abundance is anticipated relative to the No Action Alternative but the
19362 magnitude of that change is uncertain.

19363 Juvenile Fish Migration/Survival

19364 Plankton communities and shoreline habitat are not expected to change in the lower Columbia
19365 reservoirs relative to the No Action Alternative, so no changes are anticipated for juvenile shad.
19366 Shoreline habitat would decrease due to the lower Columbia River drawdowns to near
19367 minimum operating pool elevations, but the lower Snake River shoreline habitat area is not
19368 anticipated to change.

19369 Adult Fish Migration/Survival

19370 In low flow years under MO4, the proportion of adult shad counted at Bonneville Dam that
19371 migrate upstream past McNary Dam may increase due to concomitant minor increases in
19372 summer water temperatures in the John Day pool in this alternative, relative to the No Action
19373 Alternative. However, the average monthly flows for in MO4 would be higher than the No
19374 Action Alternative in some months (for example, July), and lower in other months, so overall
19375 the proportion of adult shad passing McNary Dam would likely be mixed or no effect due to this
19376 variability in temperatures and flows.

19377 **RESIDENT FISH**

19378 **Region A**

19379 ***Kootenai River Basin***

19380 Summary of Key Effects

19381 Key effects to resident fish resources under MO4 would include decreases in reservoir
19382 productivity in wet years and a delay in summer productivity in the Kootenai River below Libby
19383 Dam. Conversely, MO4 would have a greater potential for cottonwood establishment and
19384 riparian regeneration, but flows would provide the least usable habitat for bull trout, redband
19385 rainbow trout, and westslope cutthroat trout of all the MOs.

19386 Habitat Effects Common to This Fish Community

19387 MO4 would have a lower rate of flow increase from Libby Dam between mid-March and mid-
19388 May than the No Action Alternative. Under MO4, the rate of flow increase would be less than
19389 the No Action Alternative. This decrease in flow rate under MO4 would also result in a greater
19390 delay in commencement of river productivity than under the No Action Alternative.

19391 MO4 would increase the potential for cottonwood and willow seeding and recruitment
19392 compared to the No Action Alternative. Under MO4, there would be nearly three times the
19393 number of days when the winter peak stage would not exceed 1753 feet at Bonners Ferry,
19394 which is a generic surrogate for the previous year's seeding peak stage. There would also be a
19395 greater difference river elevation between the winter and spring peak stage at Bonners Ferry
19396 when compared to the No Action Alternative. MO4 would have the greatest potential of all the
19397 MOs for riparian regeneration. However, steadily increasing median flows in late summer
19398 would adversely impact varial zone productivity (i.e. inundation of previously non-wetted river
19399 margins and shifting photic zone would reduce productivity potential), but these effects could
19400 possibly be mitigated with real-time operation considerations. MO4 would have a lower rate of
19401 recession of river stage at Bonners Ferry during the seeding seasons than the No Action
19402 Alternative. This lower recession rate of MO4 would better promote cottonwood establishment
19403 than the rate under the No Action Alternative.

19404 Bull Trout

19405 Effects of MO4 to bull trout that differ from the No Action Alternative include large reductions
19406 in reservoir productivity, lower minimum and maximum water levels at Lake Kooconusa, large
19407 decreases in reservoir elevations at Libby Dam, and decreases in usable habitat for juvenile and
19408 adult bull trout.

19409 Under MO4, Lake Kooconusa would above elevation 2,450 feet for 33 days during the summer
19410 productivity period (June 15-September 15) compared to 44 days under the No Action
19411 Alternative. In dry years there would be no days with lake elevations above 2,450 feet. This
19412 would lead to reductions in maximum surface productivity potential in all but the wettest years,

19413 and especially in dry years. Primary and secondary food production would be reduced, which
19414 would likely adversely affect bull trout growth and/or survival.

19415 The median minimum and maximum elevation of Lake Kooconusa under MO4 would be the
19416 same as No Action Alternative, though drier years as measured at The Dalles would result in
19417 further decreased minimum elevations than No Action Alternative. The expected result would
19418 be more frequent annual dewatering and decreased benthic insect production, which may
19419 result in a decrease in bull trout growth and/or survival.

19420 Under MO4, the higher pool elevations during the winter associated with flood risk
19421 management and power generation could result in a colder thermal mass that warms slower in
19422 early spring. The subsequent cooler releases would delay in-reservoir and downstream
19423 productivity. This would lead to slight reductions in resident fish growth and survival. However,
19424 reservoir elevations by late April would be lower than the No Action Alternative and this would
19425 increase warming.

19426 Under MO4, Libby Dam discharge at peak flows would be lower than under the No Action
19427 Alternative. These flows provide less ability than the No Action Alternative to mobilize or
19428 reshape tributary deltas that can prevent bull trout access during the fall (low river flow).

19429 MO4 would have many more days of increasing flows than the No Action Alternative. Under
19430 MO4, the median Libby Dam discharge would drop precipitously at the end of August,
19431 desiccating benthic productivity between the late-August maximum discharge and the
19432 minimum bull trout flow of 6 kcfs. In addition, MO4 is expected to have a substantially larger
19433 adverse effect on the productivity of the varial zone of the Kootenai River downstream of Libby
19434 Dam due to steadily increasing discharge through August in years when the McNary flow
19435 augmentation measure is triggered, which would likely reduce growth and/or survival of
19436 juvenile bull trout through an adverse impact on the food web and on fish bioenergetics and
19437 metabolism. These effects could potentially be mitigated with real-time operation
19438 considerations.

19439 MO4 would have higher discharges than the No Action Alternative, but would provide less
19440 weighted usable habitat for juvenile (day and night) and adult bull trout than the No Action
19441 Alternative. MO4 would provide the least usable habitat for juvenile (day and night) and adult
19442 bull trout for all of the MOs. Given these results, lower usable habitat may result in reduced
19443 growth and/or survival of all life stages of bull trout under this alternative.

19444 Kootenai River White Sturgeon

19445 MO4 would provide 11 day less than 20 kcfs discharge compared to the No Action Alternative.
19446 This would likely result in a negligible reduction in the number of spawning adult Kootenai River
19447 white sturgeon that migrate to spawning habitat upstream of Bonners Ferry.

19448 In addition, MO4 would draft Lake Kooconusa to a lower pool elevation than the No Action
19449 Alternative for Dry and Average forecasted years. This would allow the lake to warm slightly

19450 faster. This faster warming would initiate earlier onset of spring warming in the river below the
19451 dam (via selective withdrawal) and increase summer productivity and fish growth slightly.

19452 Other Fish

19453 While the minimum and maximum elevations at Lake Koochanusa for MO4 would not differ from
19454 the No Action Alternative, on average water levels would be lower for the summer growing
19455 season. This would result in slightly less insect larvae production and less food available for
19456 resident fish species. However, on wet years MO4 would maintain higher pool elevations
19457 through the winter and spring than the No Action Alternative. This operation may be more
19458 beneficial to benthic insect production during these years.

19459 MO4 would have slightly higher discharges from Libby Dam for the period May 15 to September
19460 30 than the No Action Alternative, but would provide less weighted usable habitat for juvenile
19461 and adult redband rainbow trout than the No Action Alternative. Lower usable weighted
19462 habitat may result in reduced growth and/or survival of all life stages of rainbow/redband trout.
19463 We assumed that these effects would be similar for westslope cutthroat trout.

19464 Mean flows under MO4 as measured at Bonners Ferry between January 1 and April 30 would be
19465 slightly higher than the No Action Alternative. These flows would be slightly less likely than the No
19466 Action Alternative to provide the low flows needed for successful burbot recruitment.

19467 ***Hungry Horse/Flathead/Clark Fork Fish Communities***

19468 Summary of Key Effects

19469 The key effects of MO4 are largely biological responses to changes in Hungry Horse Reservoir
19470 elevations and outflows to provide additional water supply and flow augmentation in dry years.
19471 Lower elevations through the summer would decrease food supply for fish with minor
19472 reductions in plankton production and surface area for summer terrestrial insects in wet and
19473 average years and moderate effects in dry years. Benthic insect production important to fish
19474 would be appreciably decreased under MO4. Lower surface elevations could also increase
19475 issues with predation/exploitation risk as fish migrate into and out of tributaries to fulfill their
19476 life cycles, and increased outflows in summer would likely result in increased entrainment of
19477 zooplankton and fish out of Hungry Horse Reservoir. Increased flows in the South Fork Flathead
19478 River would be attenuated with flows from the mainstem Flathead River but would still result in
19479 higher summer flows that would decrease native fish habitat suitability in that reach. MO4
19480 would have negligible effects on Flathead Lake, lower Flathead River, or Clark Fork fish.

19481 Habitat Effects Common to This Fish Community

19482 Wet and average year types under MO4 would be similar to MO1 effects. In dry years, however,
19483 the reservoir would be drafted much deeper with higher outflows in the summer months.
19484 Modeling shows in wet and average water years the reservoir would still reach near full pool
19485 (elevation 3,560 feet) by early July in most average years and mid-July in wet years. However, in

19486 these year types the median elevation at the end of September would be 3,546 feet, or about 4
19487 to 5 feet lower than the No Action Alternative. In dry years the reservoir would still approach
19488 full pool, miss filling and typically become drawn down much faster in the same pattern as the
19489 No Action Alternative, but the dry year elevation would be a median of 10 feet lower than the
19490 No Action Alternative dry year. All year types considered, there would be a 60 percent
19491 probability of reaching elevation 3,559 feet by July 31, or 15 years more out of 100 that would
19492 not reach full compared to the No Action Alternative. In fall and winter months, MO4 would be
19493 lower than the No Action Alternative, following the same pattern as MO1 and MO3, but deeper
19494 in some years.

19495 Lake elevation in the warm summer months determines the volume of reservoir that would be
19496 available to produce plankton (euphotic zone). With lower summer elevations, the euphotic
19497 zone would decrease under MO4 in all year types, with the effect being most extreme in dry
19498 years. In early June, MO4 and the No Action Alternative are similar in wet and average years,
19499 but by July, they begin to diverge with MO4 becoming less than the No Action Alternative. By
19500 September, the euphotic zone would be from 32,000 to 37,000 acre-feet smaller than the No
19501 Action Alternative in wet and average years, representing a decrease of about 2 percent to 3
19502 percent. In dry years, the median MO4 volume would be about 89,500 af smaller than the No
19503 Action Alternative or decreased by about 7 percent. In extreme years, the elevation in dry years
19504 would be as much as 16 feet lower elevation at the end of September under MO4, which would
19505 reduce euphotic zone by about 158,000 af, or 13 percent compared to the No Action
19506 Alternative. Drawdowns any time during the year affect the production of insects that live on
19507 the bottom of the reservoir. As reservoir elevations drop, insects that have established in this
19508 zone can become dewatered. The insect eggs would have been deposited within the euphotic
19509 zone described above. If reservoir levels drop, that zone remains the same thickness and drops
19510 with the surface level, but there would be no insects deposited at the lower elevation that
19511 would become the euphotic zone. As the elevation drops, the surface for benthic insect
19512 production gets smaller. MO4 drops faster than the No Action Alternative in the summer and
19513 would be at a median of six to nine feet lower elevation through the following fall and winter.
19514 This would result in less area for benthic insect production than the No Action Alternative. In
19515 dry years there would be more severe losses, especially with more than one dry year in a row as
19516 the reservoir would go into the following water year lower and then be drawn down even
19517 further. Some of the larger aquatic insects have long life cycles that require overwintering
19518 where they were deposited; lower winter elevations would reduce the survival of these
19519 important insects. Using surface area as an index for benthic area, MO4 surface area would
19520 decrease in most months of all year types, with the exception of spring/early summer in wet
19521 years. Where decreases would be expected, they would range from about 100-over 1,000 acres
19522 compared to the No Action Alternative, or about 1 percent to 5 percent. In dry years, the
19523 summer months would have surface area 4 percent to 5 percent lower than the No Action
19524 Alternative, or a difference of about 730 to 1,030 acres. The large bays at the upper end of the
19525 reservoir could experience a proportionally higher rate of dewatering with dropping levels over
19526 the summer due to more shallow slopes where an equal drop in elevation would result in a
19527 larger dewatered benthic surface area and a considerable loss of aquatic macroinvertebrates
19528 that had been established due to desiccation.

19529 Finally, the reservoir elevation determines the surface area available for terrestrial insects to
19530 land on the water and be available for fish food, as well as influencing the proximity of the
19531 water's edge to terrestrial vegetation and therefore the ability of the two non-flying orders of
19532 important insects to be available to fish by passively landing in the water. Under MO4
19533 operations, there would be about 100 to 400 acres (1 percent to 2 percent) less surface area for
19534 summer feeding in wet and average year types and 900 to 1000 acres (4 percent to 5 percent)
19535 less in dry years.

19536 Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry
19537 Horse reservoir. The zooplankton enhances food supply in the South Fork Flathead River and
19538 along the near bank of the Flathead River but decreases food supply for fish in Hungry Horse
19539 Reservoir. Outflows, and therefore zooplankton entrainment, under MO4 would be at least 8 to
19540 17 percent higher in July and 35 to 37 percent higher in August and September, and 11111 to
19541 12 percent lower in fall through spring. These zooplankton are concentrated in the withdrawal
19542 zone in summer so the entrainment effect from increased summer outflows would be
19543 disproportionately high.

19544 Outflow patterns from Hungry Horse Reservoir can also affect how fish are entrained into the
19545 South Fork Flathead River, and the habitat conditions, such as river elevation (stage), velocities,
19546 and temperatures in the river. These effects continue downstream to affect the main Flathead
19547 River in the same patterns, but somewhat attenuated by the flows in the mainstem Flathead.
19548 Temperatures in summer are regulated with a selective withdrawal structure that is operated to
19549 release water of a temperature that favors native fish. A further departure from normative flows
19550 due to higher flows would further reduce habitat for native fish in the South Fork Flathead River.
19551 Insect production in this reach would also be affected. As modeled, the steep dip in the
19552 hydrograph in mid-June of dry years would functionally reset the life cycle of aquatic
19553 macroinvertebrates. It would take until August for the biota to recover to become a food source
19554 for fish, and by that time, the time period for fish growth would be almost over. This would result
19555 in lower growth rates for fish in the South Fork Flathead River.

19556 The temperature control structure would still operate in the summer months as in the No
19557 Action Alternative so changes in outflows in this timeframe would not affect summer
19558 temperatures downstream.

19559 In the Flathead River down to Flathead Lake, habitat suitability is a key issue in the No Action
19560 Alternative due to unnaturally high flows in the summer and winter. Under MO4, mid-July
19561 through September flows would be 14 to 22 percent higher than the No Action Alternative
19562 summer flows, and winter flows in MO4 would be slightly lower than the No Action Alternative.
19563 Spring peaks would also be slightly lower than the No Action Alternative. Winter flows would
19564 continue to limit establishment of riparian vegetation important to fish, and spring peaks only
19565 slightly lower than the No Action Alternative would continue to occasionally provide flushing of
19566 sediments from gravels to maintain habitat.

19567 The winter water temperature warming influence from the contribution of the South Fork
19568 Flathead would be slightly less due to slightly lower winter flows out of Hungry Horse. TDG in

19569 the Flathead River would be similar to the No Action Alternative, continuing to fluctuate with
19570 spill at Hungry Horse dam but, generally speaking, would not exceed 117 percent, which is
19571 within a safe zone for fish.

19572 The influence of MO4 changes to Flathead Lake levels would be minimal. Seli's Ksanka Qlispel
19573 Dam outflows would increase 5 to 12 percent in August and 6 to 7 percent in September and
19574 decrease 2 to 5 percent in April through May. Flows would be similar to the No Action
19575 Alternative in winter.

19576 Bull Trout

19577 MO4 conditions would be similar to MO1 in wet and average years, with reduced summer
19578 production of zooplankton that fuels the food web and surface area available for summer
19579 terrestrial insect feeding. In dry years, there would be further reductions to zooplankton. The
19580 lower reservoir elevations would result in substantially lower surface area for benthic insect
19581 production throughout the year, as well as desiccation of the portion of these insects that have
19582 established at elevations that become dewatered. This effect is especially in the bays at the
19583 upper ends of the reservoir lobes. Juvenile bull trout moving into the reservoir in the spring rely
19584 on the benthic insects in these areas until they transition to eating fish. The prey items that
19585 adult bull trout eat also consume these benthic insects and may be in poorer condition or less
19586 plentiful in areas. This could result in bull trout being in poorer condition.

19587 Reservoir elevations influence the access to spawning tributaries and the degree of varial zone
19588 effects such as predation risk and exposure to angling exploitation that fish experience. Bull
19589 trout spawn in the fall. Lower reservoir elevations in the fall as described in the physical habitat
19590 section would increase the risk and exposure for upstream migrating bull trout. The
19591 sedimentation of tributary deltas currently is not known, but there could potentially be
19592 blockages of passage arise with lower elevations as well. These effects would likely be
19593 moderate in wet and average years with 3 to 4 feet difference from the No Action Alternative,
19594 but dry years could see much lower elevations (up to 16 feet) and more extreme effects in
19595 years when the elevations would already be causing access and varial zone issues under the No
19596 Action Alternative.

19597 Bull trout entrainment through the dam would increase in MO4 due to increased outflows in
19598 late summer. In MO4 these outflows would be 35 to 37 percent higher than the No Action
19599 Alternative, and entrainment of bull trout would be expected to increase at least that much.
19600 Withdrawals in August and September are generally selected from deep in the water column to
19601 release the target temperature, and bull trout have been documented in this stratum at this
19602 time of year. The relationship between outflows and entrainment would likely be higher than a
19603 direct correlation because of increased risk for bull trout at this time of year. Entrainment rates
19604 of bull trout under the No Action Alternative are not known, but a considerable increase
19605 expected due to MO4 could rise to population level effects.

19606 The number of individual bull trout in the South Fork Flathead River below Hungry Horse
19607 Reservoir may increase with greater entrainment, but these would be lost from their spawning
19608 populations. Zooplankton available in the South Fork Flathead River may increase in summer with

19609 higher outflows. As in the reservoir, food web relationships are important. The MO4 Alternative
19610 would continue to allow for this transitory use by bull trout and other native fish with adequate
19611 food. Higher flows may also increase benthic production of food for bull trout prey fish, but
19612 increased velocities would result in lower availability of suitable habitat for bull trout due to
19613 higher velocities.

19614 Summer flows in the mainstem Flathead River would be higher than the No Action Alternative,
19615 further decreasing habitat suitability. Muhlfield et al. (2011) found even moderate increases in
19616 flows resulted in substantial decreases in suitable area for bull trout due to velocities, and that
19617 nighttime habitat for subadult bull trout was most sensitive. For each increase of 1,765 cfs in
19618 Flathead River flows, a decrease of 11 percent habitat would be expected. The median summer
19619 flows at Columbia Falls increase under MO4, which is expected to decrease the nighttime habitat
19620 for bull trout in this reach of river by about 6 percent. The mainstem Flathead River would be
19621 similar to the No Action Alternative in winter and spring, with barely perceptible changes from
19622 the No Action Alternative.

19623 Operations of Seli's Ksanka Qlisp'e Dam (Flathead Lake) would also result in increased outflows
19624 (6 to 12 percent higher than the No Action Alternative in the late summer months. Entrainment
19625 of bull trout would not be an issue because they would not be found near the outlets at that
19626 time of year due to warm temperatures.

19627 Other Fish

19628 Hungry Horse Reservoir favors a native fish dominated fish community. Juvenile bull trout and
19629 adult whitefish, northern pikeminnow, sculpins, and westslope cutthroat trout feed on
19630 zooplankton, aquatic insects, and terrestrial insects, and adult bull trout prey on mountain
19631 whitefish, suckers, minnows, etc. The food web effects described above would also apply to all
19632 of these species of fish in Hungry Horse Reservoir. Decreases in zooplankton and reduced
19633 summertime feeding of terrestrial insects could reduce food supply in summer. Substantial
19634 decreases in aquatic macroinvertebrate due to dewatering events and reduced surface area for
19635 production would decrease the food supply for many of these fish.

19636 Westslope cutthroat trout and other native fish spawn in the spring (April through June), so
19637 effects on adults migrating into tributaries to spawn would differ from bull trout. Spring spawning
19638 fish migrate when reservoir levels are lower and tend to experience longer varial zones with
19639 increased predation exposure. Under MO4 operations, the median modeled April and May
19640 elevations would be five and three feet lower, respectively, than the No Action Alternative. In dry
19641 years, the median elevation would remain lower than the No Action Alternative the entire
19642 summer. Spring spawning fish such as westslope cutthroat trout would experience greater
19643 considerably greater varial zone effects on their way upstream as adults, and could encounter
19644 some tributary blockages, but the delta formation of these tributaries is not known. Juveniles
19645 typically outmigrate in June. In dry years, especially, juveniles would experience higher predation
19646 risk as they outmigrate from the tributaries, through the varial zone without suitable cover, and
19647 into the reservoir.

19648 Entrainment from the reservoir of all fish species is known to occur but not quantified.
19649 Entrainment would increase under MO4, especially in late summer months with outflows up to
19650 37 percent higher than the No Action Alternative. All fish would experience increased
19651 entrainment, but northern pikeminnow and bull trout have been documented at the depths of
19652 late summer withdrawal and would be most susceptible to entrainment at rates greater than a
19653 direct correlation.

19654 Habitat suitability described for bull trout would be similar for other native fish (Muhlfield et al.
19655 2011) in the South Fork Flathead River and mainstem Flathead River, with higher summer flows
19656 in MO4 resulting in appreciably decreased amount of suitable habitat available in summer
19657 when flows are higher than the No Action Alternative.

19658 Effects to fish in Flathead Lake would be similar to conditions described in the No Action
19659 Alternative. The lower Flathead River would experience increased outflows in summer that
19660 would 7 to 12 percent higher than the No Action Alternative. This would further change
19661 conditions described in the No Action Alternative flows that tend to favor non-native fish in the
19662 lower Flathead River and Clark Fork Rivers.

19663 ***Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River***

19664 Summary of Key Effects

19665 Key effects to fish and aquatic resources under MO4 include lower summer pool elevations on
19666 dry years that may limit access to tributary habitats and reduce the quantity of important
19667 shallow water habitats.

19668 Habitat Effects Common to All Fish

19669 On dry years under MO4 Lake Pend Oreille pool elevations may be as much as 2.5 feet lower
19670 June through September compared to the No Action Alternative. This water level may limit
19671 access to tributary habitats and would represent a reduction in shallow water weedy habitats in
19672 tributary inlets that support warm water fish species.

19673 Bull Trout

19674 Effects to bull trout from MO4 include water level manipulations on drier years. Compared to
19675 the No Action Alternative water levels on dry years may be up to 2.5 feet lower under this
19676 alternative. On these drier years, access to tributary habitats during summer months may be
19677 more limited under MO4 than the No Action Alternative.

19678 Other Fish

19679 On dry years under MO4, Lake Pend Oreille pool elevations may be as much as 2.5 feet lower
19680 June through September compared to the No Action Alternative. Under these conditions, there
19681 would be a decrease in suitable habitat for warm water fish using weedy shoreline habitats
19682 near inlets. Specifically, northern pike, largemouth bass, and smallmouth bass would
19683 experience some decrease in summer habitat.

19684 **Region B**

19685 **Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam**

19686 Summary of Key Effects

19687 Flow, elevations, and water quality affect the quality of habitat for various resident fish species
19688 above, in, and downstream of Lake Roosevelt. The Columbia River from the U.S.-Canada border
19689 would continue to support a white sturgeon population that spawns successfully but primarily
19690 relies on fish manager intervention to survive a recruitment bottleneck; conditions for natural
19691 recruitment may be further diminished in a small proportion of years. In Lake Roosevelt, there
19692 would be major effects to fish. Retention time is a key metric for most fish species in Lake
19693 Roosevelt, driving the food web that supports the fish as well as influencing how many are
19694 entrained. It would be considerably lower in late spring and summer in dry years resulting in
19695 increased entrainment and decreased food supply. Lower retention times in winter would also
19696 increase entrainment risk compared to the No Action Alternative. Lake elevations under MO4
19697 would increase risk of impeded tributary habitat access and egg drying out or stranding for
19698 redband rainbow trout, especially in dry years where effects would be major and failure of year
19699 classes of some rainbow trout is likely. The portion of kokanee that spawn in tributaries would
19700 continue to have access in fall similar to the No Action Alternative in wet and average years but
19701 experience higher magnitude of varial zone effects. Reservoir operations would result in
19702 increased egg drying out of the burbot spawn and the portion of kokanee that spawn on lake
19703 shorelines compared to the No Action Alternative. MO4 would have substantial adverse impacts
19704 to native fish species, dependent on the water year. Failures of entire year classes are expected
19705 while habitat conditions are expected to improve for predatory non-native warmwater species,
19706 further expanding their range. Hatchery raised net-pen fish would be subjected to poorer water
19707 quality upon release and would likely be entrained at much higher rates and lost from the Lake
19708 Roosevelt populations. Northern pike would likely continue to increase and invade downstream,
19709 and the lake elevations could decrease the ability for boat suppression efforts. Entrainment of
19710 northern pike juveniles would likely increase and hasten the rate of invasion downstream.
19711 Reservoir fluctuation events could increase contaminant uptake by fish as this variability
19712 activates mercury into the water. Rufus Woods Lake would continue to provide habitat for fish
19713 entrained from Lake Roosevelt and from limited production of shoreline spawning by some
19714 species; entrainment could increase in spring and summer months. TDG would be similar or less
19715 than the No Action Alternative.

19716 Habitat Effects Common to This Fish Community

19717 The summary hydrograph of Lake Roosevelt water elevations influences many of the fish
19718 species in Lake Roosevelt. Refer to Chapter 3.2 for a full description of the changes in reservoir
19719 elevations. Operations would have targets to meet the metric of reaching a lake elevation of
19720 1,283 feet by the end of September, which would be met in average and wet years, but the
19721 median dry year elevation would be seven feet lower. The winter draft in MO4 would start
19722 December 1 compared to February in the No Action Alternative, and reservoir levels run about
19723 7 feet lower through these early winter months, with elevation variations shown in the

19724 modeling that would be smoother in real operations. In average and wet years, the spring and
19725 summer would be similar to MO1. Initiation of refill would be about May 1 where the levels
19726 would rise until reaching a target full pool of about 1,289 feet by early July. In dry years,
19727 however, is where MO4 differs substantially from the No Action Alternative and the MOs. The
19728 median dry year values have the reservoir failing to refill. In the beginning of May, it still would
19729 be drafting to support the McNary Dam Flow Augmentation, and it would not start to refill until
19730 June. Peak refill would be more than 20' lower the No Action Alternative as the pool would
19731 begin to draft again in July and August for augmentation flows. Median peak outflows follow
19732 the same pattern as the No Action Alternative with peaks in early June and another, smaller
19733 peak in July. The MO4 flows in early spring through August in wet and average years would be
19734 about 2 percent to 5 percent lower than the No Action Alternative. In dry years, however,
19735 outflows in May and June would increase by 5 percent to 12 percent, and then would drop to
19736 about 3 percent to 15 percent lower than the No Action Alternative flows in August,
19737 September, and October. December and January flows would be slightly (-1 percent to 4
19738 percent) higher than the No Action Alternative. These peak outflows can influence the rate of
19739 entrainment from Lake Roosevelt into Rufus Woods Lake. TDG in the Grand Coulee tailwater is
19740 also a concern for fish in Rufus Woods Lake. Under the MO4 TDG would be lower than the No
19741 Action Alternative.

19742 Retention time of water through the reservoir is a driving metric for the food web in Lake
19743 Roosevelt and influences the populations of several fish species. In MO4, retention time in
19744 December through May is related to winter FRM, Planned Draft Rate, and Upstream Storage
19745 Correction.

19746 Generally speaking, under MO4 median retention time would be considerably lower than the
19747 No Action Alternative during critical time periods for a number of fish relationships. In dry
19748 years, retention time would be much lower in May to August (29 percent, 28 percent, 21
19749 percent, and 11 percent medians in May, June, July, and August, respectively). These reductions
19750 of up to 9 days retention time could greatly affect food webs and entrainment of zooplankton
19751 and fish in the reservoir. It would be moderately higher in September and October and
19752 moderately lower in winter. In average years, retention time under MO4 would be 3 percent to
19753 9 percent lower than the No Action Alternative in the critical spring/summer months, and
19754 moderately higher in fall and moderately lower in winter. In wet years, the summer months
19755 would be similar or slightly less than the No Action Alternative, higher in October, and
19756 moderately lower through the winter. In wet years is when retention time is lowest because
19757 more water is moving through the system, and MO4 would reduce retention times even further
19758 in these years by up to 9 percent in February and by 3 percent to 9 percent in the entire period
19759 of December through May.

19760 Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely
19761 directly on the food source provided by the zooplankton production and higher-level predators
19762 such as bull trout prey on these fish. Zooplankton are more widespread, more plentiful, and
19763 larger body size when retention times are higher, and tend to be smaller bodied, swept out of
19764 the reservoir faster, and more concentrated near Grand Coulee dam with lower retention time.
19765 With lower retention times under MO4 in winter and spring, when retention times are already

19766 fairly low, there would be less food available to fish, and they would also tend to follow the
19767 food source and crowd down towards the dam, becoming more susceptible to entrainment.
19768 The large magnitude of lower retention times in summer months of dry years would be
19769 expected to increase entrainment of kokanee, redband rainbow trout, and other native fish as
19770 well as increase the invasion of non-native fish such as northern pike downstream.

19771 Bull Trout

19772 Bull trout are temperature sensitive and would continue to use this reach for foraging,
19773 migration, and overwintering habitat until temperatures reach stressful levels, which would be
19774 the same as the No Action Alternative. Bull trout in Lake Roosevelt could continue to move to
19775 cooler locations in the reservoir and these refuges would remain similar to the No Action
19776 Alternative. High flow years would continue to influence bull trout distribution through flushing
19777 more of them from the river near the U.S.-Canada border down into Lake Roosevelt. Peak flows
19778 at the U.S.-Canada border were modeled showing a decrease of about 1 percent to 2 percent
19779 under MO4, which would likely be a negligible change to bull trout distribution similar to MO1,
19780 MO2, and MO3. Increased outflows in January through May could potentially increase
19781 entrainment of bull trout, but this would be negligible because of the scarcity of bull trout in
19782 Lake Roosevelt. Bull trout prey base would continue to fluctuate, as the fish they eat are
19783 sensitive to changes in productivity and location of zooplankton in Lake Roosevelt that is
19784 influenced by the retention time of water in the reservoir, which would be adversely affected
19785 by lower retention times in MO4. In dry years, the decrease in retention time in spring and
19786 summer would tend to flush zooplankton more quickly and concentrate prey fish that bull trout
19787 eat closer to the dam, where they would be more susceptible to entrainment, especially in May
19788 when outflows would be 5 percent to 12 percent higher than the No Action Alternative. Bull
19789 trout are also sensitive to contaminants that are found in this region and would continue to
19790 bioaccumulate contaminants as a top predator. Bigger fluctuations in reservoir levels under
19791 MO4 that would increase the exposure of shorelines and the increased fluctuation events could
19792 increase methylmercury production, a highly toxic organomercury compound which
19793 bioaccumulates in fish (Willacker 2016).

19794 Other Fish

19795 In the Columbia River reach from the U.S.-Canada border to Lake Roosevelt, white sturgeon are
19796 typically able to spawn as evidenced by capture of young of the year larvae (Howell and
19797 McLellan 2018), but rarely experience successful recruitment from larvae to juvenile sturgeon,
19798 and only in extremely high water years. Successful recruitment appears to be dependent on a
19799 combination of flows exceeding 200 kcfs and water temperatures of about 14°C for 3 to 4
19800 weeks in late June/early July (Howell and McLellan 2005 Howell and McLellan 2011 and Howell
19801 and McLellan 2014). Under MO4, flow over 200 kcfs in June and July would have a slight
19802 decrease These slightly reduced flows at the U.S.-Canada border would result in a minor
19803 decrease in the recruitment window. The timing of these flows coinciding with lower reservoir
19804 levels can also increase recruitment ability with the longer riverine habitat provided by a lower
19805 reservoir. MO4 reservoir levels would be similar to MO1 in wet and average years, with slightly
19806 lower elevations. In dry years, the reservoir would be considerably lower and provide more

19807 riverine habitat length, but flows would not have been high enough for sturgeon to successfully
19808 spawn. Other factors that would continue to influence sturgeon include predation by fish that
19809 are favored by reservoir conditions if larvae are flushed into the Lake Roosevelt. Slightly lower
19810 flows in spring could slightly reduce the risk of larvae entering Lake Roosevelt. The uptake of
19811 contaminants such as copper closer to the U.S.-Canada border being flushed downstream into
19812 the reservoir by high flows would also be slightly lower. Under MO4, recruitment of white
19813 sturgeon would continue to be a rare event supplemented by hatchery propagation, as larval
19814 sturgeon are captured and raised in hatcheries until they are past the window where
19815 recruitment has been shown to fail at a high rate. Once these juveniles are released back into
19816 the reservoir they continue to grow and survive well. The reservoir would continue to provide
19817 good conditions for growth and survival of these fish. In dry years there would be more riverine
19818 habitat and less lake-like habitat, which could tend to favor white sturgeon juveniles over non-
19819 native species.

19820 Wild production of native fish such as burbot, kokanee, and redband rainbow trout would be
19821 impaired for populations in Lake Roosevelt. As described in the common habitat effects, these
19822 fish are the most sensitive to the effects of changing retention times. Under the No Action
19823 Alternative an estimated average of over 400,000 fish annually would be entrained, with 30 to
19824 50 percent of them being kokanee, primarily of wild origin and rainbow trout the second most
19825 entrained species. Under MO4 operations, greatly increased entrainment would be expected in
19826 spring and summer months of dry years as the outflows increase over the No Action Alternative
19827 and retention times are up to 9 days or 30 percent faster. Summer months were found to be
19828 the months with the highest rates of entrainment, and in years of high entrainment May, June,
19829 and July losses were estimated in the range of about 90,000 to up to 200,000 fish per month
19830 (LeCaire 2000) under the No Action Alternative. Increases of 30 percent in these months would
19831 likely decrease populations of kokanee and rainbow trout. Wild kokanee would likely be the
19832 majority of fish entrained. Entrainment would also be expected to increase in winter in all year
19833 types, and December through May in wet years.

19834 The decreased retention time in spring and summer of average and dry years, especially, would
19835 also likely adversely affect food sources for fish in Lake Roosevelt to the point of affecting
19836 growth of kokanee and other fish. Increased entrainment of zooplankton in winter would
19837 decrease food availability that is key to winter survival and growth of several fish species
19838 including kokanee, juvenile burbot, and other juvenile fish, though this effect would be
19839 somewhat mitigated with increased retention times in September and October that would flush
19840 fewer of these zooplankton out in the fall than under the No Action Alternative.

19841 For tributary spawning species such as redband rainbow trout and a portion of the wild
19842 production of kokanee, tributary access at the right time of year is important. Reservoir
19843 drawdown in the spring creates barren tributary reaches through the varial zone, which directly
19844 and indirectly impedes migration to and from tributaries and the reservoir. The operational
19845 metric of reaching a lake elevation of 1,283 feet by the end of September would be met under
19846 MO4 in average and wet years, but would be about median dry years would be 7 feet lower and
19847 levels would be lower than the No Action Alternative in October through December as well.

19848 Lower elevations could impede access and increase predation risk and increase volitional
19849 migration time for kokanee. Redband rainbow trout need access tributaries in the spring. Under
19850 MO4, reservoir elevations would be slightly lower than the No Action Alternative levels in the
19851 critical spawning migration time of April and May in wet and average years, and considerably
19852 lower in dry years. This would be most extreme in dry years, with large deviations from the No
19853 Action Alternative levels, but also most critical in wet years (20 percent of years) when the
19854 median elevation would be 1,217 ft at the lowest point in early May, 5 feet lower than the No
19855 Action Alternative. Migratory impacts although not well documented, could be severe for
19856 Redband rainbow trout given the timing and extent of drawdowns in MO4. Specific tributaries of
19857 concern that redband rainbow trout spawn in Sanpoil, Blue Creek, Alder, Hall Creek, Nez Perce
19858 Creek, Onion Creek, Big Sheep Creek, and Deep Creek. These tributaries higher in the basin are
19859 more susceptible to elevation changes because a smaller change in lake elevation would result
19860 in a larger area of exposure than tributaries closer to the dam. Additionally, increased exposure
19861 during migrations to these tributaries would increase the varial zone effect where migrating fish
19862 are more exposed to predation and angling due to lack of cover.

19863 Species such as kokanee and burbot that spawn on shorelines in Lake Roosevelt are susceptible
19864 to egg desiccation if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on
19865 shoreline gravels September 15 to October 15 and eggs incubate through February. Burbot
19866 tend to spawn successfully in depths provided by MO4 in the Columbia River and in Lake
19867 Roosevelt on shorelines near the Colville River in winter with eggs incubating through the end
19868 of March (Bonar et al. 2000). MO4, compared to the No Action Alternative, begins dropping 2
19869 months sooner and would likely strand or dewater burbot and kokanee eggs more than the No
19870 Action Alternative. A higher proportion of eggs at all elevations would be affected in all year
19871 types due to fluctuations in the modeled elevations, although these could be smoothed out
19872 somewhat in real-time operations. MO4 dry year scenarios would strand and desiccate
19873 considerably more eggs and larvae than the No Action Alternative in January and February with
19874 differences up to ten feet.

19875 Fry sometimes also stay in the gravels and could become stranded as well. The wet years would
19876 have steeper and deeper reservoir draft than the No Action Alternative and would result in
19877 increased stranding of burbot eggs. Burbot spawn in the Columbia River above Lake Roosevelt
19878 and in reservoir towards the upper end; the river spawning fish would not be as susceptible to
19879 reservoir fluctuations.

19880 Kokanee are very sensitive to water temperature, and during summer are found at depths below
19881 120 m to find suitably cool water. Similar to the No Action Alternative, Lake Roosevelt is very
19882 weakly stratified but does have suitably cool water at this depth along with suitable levels of DO.
19883 Lake whitefish and mountain whitefish also likely use this cool water in the summer.

19884 Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish,
19885 crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all
19886 tolerate a wide range of environmental conditions and would continue to contribute to the
19887 fishery community under the No Action Alternative, and continue to adversely impact native

19888 species via predation. The invasion downstream by northern pike is of concern, and the Lake
19889 Roosevelt Co-Managers are actively suppressing pike populations using gillnets set by boats as
19890 soon as they can get on the water in the spring until the boat ramp becomes unusable at elevation
19891 of 1,235 feet. Under the No Action Alternative, this occurs on April 15 in wet years and ramps
19892 remain useable in dry and average years. Under MO4 in wet years, this would occur up to 6 days
19893 sooner, and in dry years the elevation could also drop to this level in May and June, though that is
19894 likely after pike would already have spawned. Like MO1, MO4 operations could preclude the
19895 ability for the pike suppression efforts for that time period when boat ramps would be
19896 inaccessible. For estimation purposes, one crew typically removes about 100 pike per week and
19897 they would operate three crews (Colville Tribe unpublished data), so opportunity lost of up to 6
19898 days under MO4 in wet years and potentially some additional time in dry years could result in an
19899 estimated 300 or more pike not removed. It should be noted that is only one boat ramp, but the
19900 middle of Lake Roosevelt area becomes inaccessible earlier, at lake elevation 1,245' or slightly
19901 lower. Additionally, outflows and retention time would continue to influence the entrainment and
19902 downstream invasion of non-native gamefish below Chief Joseph Dam where ESA-listed
19903 anadromous salmonids would be susceptible to predation by them. During the time when pike
19904 juveniles would be most susceptible to entrainment (May to August), retention time under MO4
19905 would be up to 30 percent lower and entrainment risk would be considerably higher than the No
19906 Action Alternative. Additionally, as adult pike distribution increases downstream in the reservoir,
19907 adults and juveniles both would become more susceptible to entrainment and the higher outflows
19908 any time of year would increase entrainment. Overall these effects would likely hasten the
19909 invasion of northern pike downstream, which could result in an increased risk of predation to
19910 salmon and steelhead.

19911 Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt
19912 would experience similar effects as their native counterparts except for spawning and early
19913 rearing effects. In addition, the net pen locations are situated where the water quality can be
19914 affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG,
19915 and their eventual recruitment to the fishery can be affected by retention time coupled with
19916 reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May.
19917 Under the MO4, the water quality at these locations would be similar to the No Action
19918 Alternative except for modeled decreases in dissolve oxygen in the Spokane arm. This could
19919 decrease habitat suitability for the fish in that location. The operators strive to release these
19920 fish to coincide with the initiation of reservoir refill when outflows are reduced, which under
19921 MO4 wet and average years would be similar to the No Action Alternative and these fish would
19922 continue to be release when water quality conditions would be suitable. In dry years, however,
19923 initiation of refill would be delayed by up to four to six weeks later than the No Action
19924 Alternative. This delay would result in releasing hatchery fish later where they would likely
19925 encounter more stressful rearing conditions with higher temperatures and TDG. If the fish were
19926 released at similar time as the No Action Alternative but the refill is delayed, these fish would
19927 be subject to much higher risk of entrainment due to low retention times and higher outflows
19928 in May and June. Conditions in dry years would already be stressful to fish, and these conditions
19929 would be exacerbated by the delay in release.

19930 The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake
19931 Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter
19932 drawdown periods. MO4 operations would likely considerably increase entrainment in spring
19933 and summer, boosting fish populations in Rufus Woods Lake, where decreased outflows in
19934 August and September likely would decrease entrainment. This lake has more riverine
19935 characteristics with steep gradients and narrow canyon walls, making it more like a river than a
19936 reservoir, with short retention time and low productivity. High flows during late spring and
19937 early summer would continue to flush eggs and larvae from protected rearing areas similar to
19938 the No Action Alternative, but at a higher magnitude in dry years. Median peak outflows occur
19939 in early June and would be about 3 percent lower than the No Action Alternative in wet and
19940 average years but higher in dry years. TDG in the Grand Coulee tailwater is a concern for fish in
19941 Rufus Woods Lake; modeling showed TDG would be lower than the No Action Alternative.

19942 ***Chief Joseph to McNary Dam***

19943 Summary of Key Effects

19944 Changes in key effects to fish and aquatic resources in this reach of the Columbia River under
19945 MO4 relative to the No Action Alternative include slight decreases in flows during May and June
19946 and minor increases in water temperatures during June and July similar to effects seen for
19947 MO1. In addition, seasonal fluctuations in water levels could occur in the McNary pool.

19948 Habitat Effects Common to All Fish

19949 The main habitat effect common to all fish under MO4 would be the greater degree of McNary
19950 pool fluctuation under this alternative. MO4 allows for a drawdown of 1 foot on average years,
19951 while on the driest years there may be a drawdown of 3.5 feet. This level of drawdown could
19952 adversely impact shallow water rearing and nesting habitats for warm water fish species and
19953 shallow water macroinvertebrates.

19954 Bull Trout

19955 Under MO4, there would be slight increase in water temperature in June and July. These higher
19956 temperatures may have minor added stress to bull trout and may induce them to leave the
19957 mainstem earlier in the year when compared with the No Action Alternative.

19958 Other Fish

19959 Key effects to white sturgeon from MO4 would include slightly lower spring peak flows in most
19960 years and slightly higher water temperatures upstream of McNary pool when compared to the
19961 No Action Alternative. In low water years there would be higher flows in May and June than the
19962 similar type of years in the No Action Alternative. While this may provide a minor survival
19963 benefit, sturgeon spawning and recruitment would not be successful in low water years of
19964 either alternative. The number of days in the year when water temperature would be over 21°C
19965 was used to evaluate temperature effect to white sturgeon. Under the No Action Alternative,
19966 there were about 5 days over this threshold while there were over 11 days under MO4. The

19967 effect of this change in water temperature would be a minor increase in risk of mortality to
19968 white sturgeon under this alternative.

19969 Key effects of MO4 to fish species in this reach of the river that differ from those of the No
19970 Action Alternative include a slight increase in survival of juvenile salmon and steelhead that
19971 would increase forage for resident predator species, and potential McNary pool water level
19972 drawdowns of 1 to 3.5 below current operations that may affect rearing and survival of some
19973 warm water fishes. Under MO4 juvenile salmon and steelhead survival would be expected to
19974 increase by about 1 percent and provide an increase in forage for walleye, smallmouth bass,
19975 and northern pikeminnow. Currently, water levels are held relatively stable at McNary pool.
19976 Under MO4, there could be a drawdown during May and June of 1 foot in most years and up to
19977 3.5 feet in dry years. This drawdown could leave smallmouth bass nests and walleye rearing
19978 areas dry and reduce egg and fry survival for these and other shallow nesting or rearing species.

19979 **Region C**

19980 ***Snake River Basin***

19981 Summary of Key Effects

19982 Changes in key effects to fish and aquatic resources in this reach of the Snake River under MO4
19983 relative to the No Action Alternative include increases in spill and TDG concentrations March
19984 through August and a potential to delay upstream dam passage for bull trout or other
19985 migratory species.

19986 Habitat Effects Common to All Fish

19987 The habitat effects common to all fish under MO4 would be the greater exposure to elevated
19988 TDG concentrations that results from increased spill.

19989 Bull Trout

19990 Effects of MO4 to bull trout in the Snake River that differ from the No Action Alternative include
19991 additional spill that may cause delays in bull trout upstream passage at the dams in May and
19992 June when the fish are moving out of the system to avoid warming water temperatures.

19993 Elevated TDG levels from spill under MO4 may adversely affect an unknown number of bull
19994 trout in the reservoirs by degrading feeding, migrating, and wintering habitat in the mainstem
19995 Snake River. Under MO4, a total of 48.3 percent of all modeled days from November through
19996 June would have TDG concentrations over 110 percent, which is the highest number of all the
19997 MOs and exceeds the No Action Alternative by more than 10 percent. Higher TDG may affect
19998 bull trout in May and June when they are leaving the system.

19999 Other Fish

20000 Under MO4, white sturgeon fry would experience an increase in exposure to high TDG from
20001 April through July and a major increase in parts of April and May relative to the No Action
20002 Alternative. Modeling shows under MO4 TDG levels would be greater than 120 percent for 52.9

20003 percent of that time period, with a high of 136 percent TDG. This is an increase from only 9.8
20004 percent under the No Action Alternative and is also higher than any of the MOs. This would
20005 likely have adverse effects on white sturgeon fry.

20006 Other resident fish would be affected by TDG as well. When compared with the other MOs,
20007 warm water fish species that rear near the surface would be subject to increased TDG Exposure
20008 in their rearing habitat from April through July and major increases in parts of April and May
20009 when compared with the No Action Alternative.

20010 **Region D**

20011 **Mainstem Columbia River from McNary Dam to the Estuary**

20012 Summary of Key Effects

20013 Bull trout would continue to use the Columbia River in limited numbers and seek thermal
20014 refugia available at the mouths of tributaries. White sturgeon could continue to successfully
20015 reproduce in years with adequate flow and temperature conditions (sturgeon recruitment
20016 failure could continue to occur independent of CRSO operations).

20017 Habitat Effects Common to this Fish Community

20018 Outflows from McNary Reservoir influence some of the fish relationships described in this
20019 section. Peak spring flows affect habitat maintenance for some species. Modeled median
20020 outflows for MO4 are shown below. The percent change compared to the No Action Alternative
20021 is shown in parentheses.

- 20022 • April: 186000 (-3 percent)
- 20023 • May: 255800 (-2 percent)
- 20024 • June: 282700 (-1 percent)
- 20025 • July: 198500 (no change)

20026 Other flow parameters referred to in this section refer to outflows of McNary Dam, which are
20027 indicative of flows on downstream through the other projects.

20028 Bull Trout

20029 Bull trout are known to use the mainstem Columbia River to move between tributaries and
20030 have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et
20031 al. 2016). Water temperature is the most important habitat factor for bull trout in the
20032 mainstem Columbia. Under MO4, bull trout would continue to use the mainstem Columbia for
20033 migration between tributaries, as well as tributary mouths for passage and thermal refugia.

20034 Adult bull trout move downstream during fall and overwinter in reservoirs (October to
20035 February; Barrows et al. 2016). Although bull trout successfully move between areas on the
20036 mainstem, their migration can be delayed at the dams. MO4 includes structural measures for

20037 additional spillway passage at McNary and John Day Dams. This measure would be in operation
20038 from March 1 through August 31, and could slightly improve bull trout downstream passage,
20039 but the majority of adult bull trout would have moved out of the mainstem by the time this
20040 surface passage route would be in use.

20041 Passage through turbines can cause injury or mortality. MO4 includes turbine replacement with
20042 IFP turbines, which would improve survival (Deng et al. 2019). At John Day, turbine replacement
20043 would provide safer passage for any bull trout that move through the dam.

20044 Bull trout would continue to be subject to bird predation under MO4 at similar levels to the No
20045 Action Alternative.

20046 Other Fish

20047 Under MO4, spawning and recruitment of white sturgeon would be similar to the No Action
20048 Alternative in average and wet years. In years of low flow conditions, water temperatures could
20049 increase beyond the suitable range by early June, resulting in little or no recruitment. White
20050 sturgeon spawning generally occurs in areas with fast-flowing waters over coarse substrates
20051 (Parsley et al. 1993). Minor changes in outflow under MO4 would not be large enough to cause
20052 discernable velocity changes that would affect sturgeon spawning habitat. Lack of effective
20053 upstream white sturgeon passage for all age classes decreases the connectivity of the
20054 population (Parsley et al. 2007). Under MO4, improvements to turbines at John Day Dam could
20055 reduce injuries and mortality of sturgeon.

20056 White sturgeon larvae are adversely affected by TDG. Adults are more able to compensate for
20057 increased TDG by moving to lower depths, but larvae in shallow water would be more affected.
20058 Under MO4, TDG rates would be higher than No Action Alternative. All four dams in this reach
20059 would have a prolonged increase of TDG from 120 percent to about 125 percent TDG. This
20060 would result in detrimental effects to juveniles and larvae. Changes in a pool or tailrace
20061 elevation can affect juvenile white sturgeon through stranding in shallow water. Under MO4,
20062 John Day, The Dalles, and Bonneville Dam would all draw down to the minimum operating pool
20063 from late March to mid-August. This would be unlikely to result in stranding, since the
20064 drawdown would occur before spawning, but it could result in less shallow water habitat being
20065 available for juvenile and larval sturgeon.

20066 Under MO4, no changes to other resident fish communities would be expected, though all fish
20067 would be subjected to higher TDG levels than the No Action Alternative. As shown above,
20068 outflow rates below McNary Dam would be very similar to the No Action Alternative. Water
20069 quality and food availability would also be similar to the No Action Alternative.

20070 Conditions that promote lower water temperatures and higher spring flows tend to lower the
20071 survival rates of warmwater game fish, potentially lowering populations of predators on salmon
20072 and steelhead. MO4 would be expected to continue supporting warmwater game fish at levels
20073 similar to current conditions. Increased spill under MO4 could have slight adverse effects on
20074 northern pikeminnow.

20075 **MACROINVERTEBRATES**

20076 Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under MO4. For more
20077 detailed information on the effects of MO4 on aquatic invertebrates and implications on food
20078 web interactions see the Habitat Effects section of these respective fish community analyses in
20079 the Resident Fish section under the applicable region.

20080 **Region A**

20081 At Hungry Horse reservoir, the wet and average years operations under MO4 would be similar in
20082 operations to MO1 (see the discussion of macroinvertebrates in Section 3.5.2.3). In dry years, the
20083 reservoir would be drafted much deeper with higher outflows in the summer months. The varial
20084 zone that provides benthic insect production would be appreciably reduced due to steeper drafts
20085 in the summer and lower elevations through the winter months, and aquatic insects in this zone
20086 would become dewatered faster than under the No Action Alternative. The reservoir would miss
20087 filling in 15 more years out of 100 compared to the No Action Alternative, and the elevation at
20088 the end of September would be 4 to 5 feet lower than the No Action Alternative in wet and
20089 average years, but up to 16 feet lower in dry years. Habitat for aquatic insects would be
20090 considerably reduced in these years, and benthic insects would be dewatered in a larger area.

20091 With lower summer elevations, the area available for summer zooplankton production would
20092 decrease by up to 89,500 to 158,000 acre-feet, or by about 7 percent to 13 percent.
20093 Additionally, zooplankton would be flushed out of the reservoir and downstream at a rate that
20094 would be much higher than the No Action Alternative in July, August, and September of all
20095 years. Fewer zooplankton would be flushed out of the reservoir, compared to the No Action
20096 Alternative, in spring, fall, and winter. These outflow changes would increase zooplankton
20097 levels and wetted area for macroinvertebrate production in the South Fork Flathead River but
20098 could also flush more out of South Fork Flathead River with higher velocities. This pattern
20099 would continue (though at reduced levels) into the mainstem Flathead River.

20100 MO4 operations would result in minimal changes to Flathead Lake, but the lower Flathead River
20101 would see 5 to 12 percent higher flows in August and 6 to 7 percent higher in September. These
20102 flows would potentially flush macroinvertebrates, including opossum shrimp, out of Flathead
20103 Lake, and increase habitat in the lower Flathead River for invertebrate production. The Clark
20104 Fork River macroinvertebrate communities would be similar to the No Action Alternative.

20105 The operations of the Albeni Falls Project would be similar to the No Action Alternative in wet
20106 and average years, where operations would not result in appreciable changes to Lake Pend
20107 Oreille or the Pend Oreille River, nor the macroinvertebrate communities in those habitats. In
20108 dry years, however, Lake Pend Oreille would fill to elevation 2059.7 feet, which is about 2.5 feet
20109 lower than the No Action Alternative. This would result in a reduction of habitat available for
20110 aquatic macroinvertebrates through the summer. However, the No Action Alternative elevation
20111 drops about a foot through the month of September where the MO4 elevation would hold
20112 steady, so the aquatic macroinvertebrates produced would not experience the dewatering
20113 event as in the No Action Alternative. Increased outflows from mid-May through June would

20114 flush more zooplankton past the dam, but this would be reduced with lower outflows in
20115 September. These higher May-June flows would benefit macroinvertebrates in the Pend Oreille
20116 River as the river levels would hold about 10 percent higher for about a six-week period rather
20117 than dropping and dewatering habitat as in the No Action Alternative.

20118 In the Kootenai Basin, Lake Kooconusa would not have any days over where the water elevation
20119 would be greater than 2,450 feet in average or dry years. In average years, MO4 operations
20120 result in a median minimum pool elevation from 4 to 5 feet lower than the No Action
20121 Alternative throughout the summer months. The rate of drop through the summer would be
20122 similar to the No Action Alternative in average years. In the winter months, the water elevation
20123 would drop at a less steep rate than the No Action Alternative. This operation would decrease
20124 the overall productivity of zooplankton and macroinvertebrates in the system overall through
20125 the warm, productive summer months. In average years, the benthic production would be at a
20126 lower level than the No Action Alternative but not subjected to any additional dewatering in
20127 summer, and fewer insects would be dewatered in the winter months compared to the No
20128 Action Alternative. In dry years, however, the pool level would be similar to the No Action
20129 Alternative in early July, but drop at a much steeper rate and end the water year a median of 13
20130 feet lower than the No Action Alternative, exposing more varial zone as the summer goes on
20131 and dewatering a large portion of the insect production that would have established in the top
20132 thirteen feet of the inundated area.

20133 **Region B**

20134 The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic
20135 insects such as stonefly, caddisfly, and mayfly larvae. The river elevation in this reach is
20136 influenced by Lake Roosevelt operations and inflows so is somewhat variable, which would
20137 constrain benthic production to some degree in a reduced capacity.

20138 MO4 operations would change river elevations at the U.S.-Canada border throughout much of
20139 the year and differ by year type. Wet and average years would be somewhat similar to MO1,
20140 with lower elevations in the winter (see the discussion of macroinvertebrates in Section
20141 3.5.2.3). MO4 would result in water elevation drops compared to the No Action Alternative,
20142 with the stage dropping from the beginning of November through March in all year types, and
20143 there would be more fluctuations in stage. Steeper drops in water elevation and more
20144 variability would reduce suitable habitat for macroinvertebrate production and cause multiple
20145 desiccation events, likely limiting productivity in winter. Additionally, dry years would see river
20146 stage elevations a median of about 5 feet lower than the No Action Alternative from late June
20147 through October. This would limit habitat for the production of macroinvertebrates in the
20148 summer in dry years. Wet and average years would also be lower than the No Action
20149 Alternative, but only about 2 to 3 feet. This change in elevation represents the vertical feet;
20150 actual habitat dewatered would depend on the slope of the riverbanks at this elevation. As the
20151 river flows downstream closer to Lake Roosevelt, the pattern is the same but the additional
20152 drop from MO4 in dry years would result in about sixteen feet lower elevation at river mile 720.

20153 This would indicate the magnitude of lost benthic habitat and desiccation would become
20154 increasingly severe as the river experiences more influence from Lake Roosevelt fluctuations.

20155 Generally speaking, under MO4 median retention time would be considerably lower than the
20156 No Action Alternative during critical time periods for a number of fish relationships. In dry
20157 years, retention time would be much lower in May-August (29 percent, 28 percent, 21 percent,
20158 and 11 percent medians in May, June, July, and August, respectively). These reductions of up to
20159 9 days retention time could greatly affect production and entrainment of zooplankton in the
20160 reservoir. It would be moderately higher in September and October and moderately lower in
20161 winter. In average years, retention time under MO4 would be 3 percent to 9 percent lower than
20162 the No Action Alternative in the critical spring/summer months, and moderately higher in fall
20163 and moderately lower in winter. In wet years, the summer months would be similar or slightly
20164 less than the No Action Alternative, higher in October, and moderately lower through the
20165 winter. In wet years is when retention time is lowest because more water is moving through
20166 the system, and MO4 would reduce retention times even further in these years by up to 9
20167 percent in February and by 3 percent to 9 percent in the entire period of December through
20168 May.

20169 The elevations in Lake Roosevelt would follow the same pattern as in the river sections
20170 described above, with MO4 elevations dropping further through the winter and being more
20171 variable. In dry years, the summer elevation would continue to drop from May to July and
20172 would be up to 22 feet lower than the No Action Alternative in this time period. This would
20173 result in desiccation of more aquatic macroinvertebrates and overall decreased habitat, likely
20174 severely reducing benthic productivity in dry years. Wet and average year types would also see
20175 loss of benthic production but less severe. More than one back-to-back dry year would intensify
20176 these effects.

20177 Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with
20178 steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short
20179 retention time and low productivity. Regarding aquatic insect production and desiccation, river
20180 stage at RM 594 in Rufus Woods Lake would also experience effects differently by year type.
20181 Wet and average years would be similar pattern at slightly lower elevation through the spring
20182 and summer, and then in November through March experience steeper drops and swings that
20183 are more variable in stage than the No Action Alternative. This would reduce production
20184 capability. In dry years, this pattern would be similar except for the months of May through
20185 June, when additional flow would be released, raising stage and increasing velocities above the
20186 No Action Alternative dry year levels, and then July through August would be lower. This late
20187 summer period drop in stage could dewater more aquatic inverts produced in May and June.

20188 **Region C**

20189 Dworshak Reservoir elevations would be the same as the No Action Alternative. Benthic
20190 production in the reservoir would continue to be low due to the extensive variation in water
20191 surface elevation, near-shore wave action that causes erosion, and the lack of aquatic plants
20192 along the shoreline. Likewise, outflows would be the same as the No Action Alternative. Benthic

20193 communities in the Clearwater River below Dworshak Reservoir would continue to be limited
20194 by unsuitably high flows in summer and late winter.

20195 The macroinvertebrate community of the lower Snake reservoirs and river would continue
20196 similar to the No Action Alternative. Siberian prawns and opossum shrimp may continue to
20197 increase in the reservoir environments. The reservoirs would continue to provide habitat for
20198 clams, mussels, etc., as in the No Action Alternative, and crayfish would find ample suitable
20199 habitat in the rock and riprap of reservoirs. Soft substrates of the reservoirs would continue to
20200 be dominated by low species diversity, mostly worms. Harder substrates would provide habitat
20201 for a relatively poor diversity of aquatic insect larvae.

20202 **Region D**

20203 MO4 would result in only minor changes to flows or temperatures that could affect
20204 macroinvertebrate communities in the lower Columbia River. Very little benthic
20205 macroinvertebrate information is available for the lower Columbia River. Lake habitats in the
20206 impounded reaches would continue to support a low diversity of worms, benthic insects, and
20207 mollusks. In MO4, John Day, The Dalles, and Bonneville Dams would all draw down to the
20208 minimum operating pool from late March to mid-August. The drawdown period in late March
20209 would likely result in stranding and desiccation of considerable numbers of aquatic
20210 macroinvertebrates, but there would still be ample habitat to continue production.

20211 **SUMMARY OF EFFECTS**

20212 **Anadromous Fish**

20213 MO4 includes structural and operational measures that were intended to increase adult salmon
20214 and steelhead returns through improved juvenile migration and survival. These measures
20215 include incremental improvements in powerhouse surface passage routes and improved
20216 survival of fish that go through the turbines. Large increases in spill compared to the No Action
20217 Alternative, lower river reservoir drawdowns, and additional flow augmentation in dry years
20218 would be expected to decrease the travel time of in-river fish and decrease powerhouse
20219 encounter rates. With the increased spill volumes, TDG exposure would increase substantially
20220 compared to the No Action Alternative. Structural measures such as powerhouse surface
20221 collectors did not result in substantial increases in juvenile survival or improvements in adult
20222 returns.

20223 The potential benefits of MO4 for salmon and steelhead varies greatly depending on which
20224 model is used. The CSS model predicts large increases in Spring Chinook salmon and steelhead
20225 to the Snake River. These increases are predicted based on increased spill levels that would
20226 increase the number of fish passing via the spillways and avoiding powerhouses, which the CSS
20227 models predict would reduce latent mortality associated with CRS passage. Snake River spring
20228 Chinook and steelhead SARs are modeled to improve by 70-75 percent relative to the No Action
20229 Alternative.

20230 The LCM predicts minor increases in benefits to Upper Columbia spring Chinook and steelhead
20231 (two percent relative increases in SARs and downstream survival). However, for Snake River
20232 spring Chinook, the model predicts that unless changes in passage through the CRS can increase
20233 ocean survival by 10 percent (i.e. latent mortality effects are decreased by 10 percent), the net
20234 impact to Snake River Chinook salmon would be adverse (a relative decrease in SARs of 12
20235 percent). This potential decrease in overall adult returns is primarily driven by reductions in
20236 transportation rates due to high spill, a relationship that could be similar for Snake River
20237 steelhead.

20238 MO4 also includes structural modifications to infrastructure at the dams to benefit passage of
20239 adult salmon, steelhead, and Pacific lamprey. The objective to improve resident fish for would
20240 not be met in the upper basin due to the deep drafts to the upper basin storage projects. There
20241 is also the potential for negative effects to resident fish due to increased prolonged exposure to
20242 elevated TDG levels in the lower basin.

20243 Overall, predicted effects from this MO are expected to range from moderate adverse to major
20244 beneficial. These effects vary widely by species.

20245 **Resident Fish**

20246 MO4 has effects ranging from minor to major adverse for resident fish. In Region A, decreases
20247 in reservoir productivity are expected in all years and would be further exacerbated in wet
20248 years. A delay in summer productivity in the Kootenai River below Libby Dam would also
20249 adversely affect fish. Conversely, MO4 would have a greater potential for cottonwood
20250 establishment and riparian regeneration, a moderate beneficial effect, but flows would provide
20251 the least usable habitat for bull trout, redband rainbow trout, and westslope cutthroat trout of
20252 all the MOs. At Hungry Horse Reservoir, moderate to major effects from decreased reservoir
20253 levels and increased summer outflows in dry years include loss of productivity, diminished
20254 tributary access, increased entrainment, and degraded habitat in the Flathead River. In most
20255 water years, these effects would be similar to MO1; in dry years, they would be more adverse
20256 due to releases to support downstream flow augmentation. In areas such as Lake Pend Oreille,
20257 lower reservoir elevations in dry years may limit access to tributary habitats and reduce the
20258 quantity of important shallow water habitats. Increased TDG associated with higher levels of
20259 spill may have effects on bull trout during months where they are leaving the system. Region B
20260 would also see moderate to major effects, particularly in dry years when Lake Roosevelt would
20261 be drawn down deeper and summer outflows would increase. Changes in retention time would
20262 reduce food availability and increase loss of fish through Grand Coulee dam. This increased
20263 entrainment would likely hasten the invasion of northern pike downstream with increased
20264 entrainment and reduced suppression capability. Tributary access for wild fish spawning and
20265 water quality for net-pen raised fish would both be affected, and more eggs would be affected
20266 by dewatering; potentially losing entire year classes of some species of native fish. In Regions C
20267 and D, resident fish would be affected by increased TDG.

20268 **Macroinvertebrates**

20269 Lower summer elevations in certain areas would reduce habitat for summer zooplankton
20270 production, while higher levels of flows during summer months would flush certain
20271 macroinvertebrates in areas such as Flathead Lake, while increasing habitat in areas such as the
20272 lower Flathead River for invertebrate production. Elevations at Lake Roosevelt would become
20273 more variable, reducing benthic productivity in dry years. In Regions C and D, elevations, flows,
20274 and temperatures would be similar to the No Action Alternative and would result in negligible
20275 effects. Overall, effects are expected to be minor to moderate.

20276 **3.5.4 Tribal Interests**

20277 Fish are of great cultural importance to tribes in the study area and have fundamental roles in
20278 diet, medicine, and cultural identity. For virtually all tribes in the region, fish are part of the
20279 history of subsistence and important to public health. The CRS dams are viewed by tribes as an
20280 impediment to the aquatic resources that are essential to the tribal way of life. For example,
20281 the lower Snake River dams are seen as an adverse impact for tribes that rely on the Snake
20282 River aquatic resources.

20283 Each tribe has a personal, cultural, spiritual, and commercial connection with the rivers around
20284 them. For instance, the Kootenai Tribe of Idaho and *Yaqaan Nukiy*, the main source of
20285 subsistence historically was fishing. The Kootenai River itself became part of the Tribe's identity
20286 and historically there were a number of camp locations along the River such as at Jennings,
20287 Montana.

20288 This fish analysis evaluates how MOs impact survival of adult and juvenile salmon and resident
20289 fish in the study area in comparison to the No Action Alternative. In terms of how those MOs
20290 would impact Tribal Interests, the co-Lead Agencies assume that if more adult salmon,
20291 steelhead lamprey, and other anadromous fish are returning to the Columbia River and its
20292 tributaries and resident fish conditions improve, then there would be more fish available for
20293 harvest. However, because of the differences in life histories, habitat requirements, and effects
20294 across the four regions due to operations, the analysis and results are very complicated and
20295 effects to tribes would be based on location and the fish species important to that tribe.

20296 In general, however, the analysis describes the following effects.

20297 **3.5.4.1 Salmon and Steelhead**

20298 In comparison to the No Action Alternative, Upper Columbia River salmon and steelhead would
20299 generally see similar or minor increases in juvenile and adult returns for MO1, MO3, and MO4
20300 unless ocean survival improves due to reductions in latent mortality. Tribal members that
20301 harvest these populations for subsistence, recreation, or commercial fisheries may see an
20302 increase in numbers of fish return, except under MO2. MO2 would result in decreased
20303 abundance for these fish.

20304 Snake River salmon and steelhead would see minor improvements under MO1. MO2 would
20305 result in decreases in juvenile survival and adult abundance. MO3 would have short-term

20306 construction related effects but could lead to long-term increases in adult returns. Fall Chinook
20307 spawning habitat would increase. MO4 would increase juvenile survival, but adult survival could
20308 decrease. In addition to the differences in impact on tribal members that harvest these fish
20309 under each MO, there are also differences in the impacts within the MOs based upon which
20310 model has been used.

20311 **3.5.4.2 Other Anadromous Fish (coho, chum, eulachon, green sturgeon, lamprey)**

20312 MO1 would have minor decreases for coho and chum with mixed impacts for lamprey.
20313 Eulachon and green sturgeon numbers would be similar to the No Action Alternative. There
20314 would be decreased juvenile survival for MO2 for these species. Under MO3, there would be
20315 minor increases in abundance in the lower and middle Columbia reaches for eulachon and
20316 green sturgeon, while coho and chum would be similar to the No Action Alternative. MO4
20317 would have minor benefits for lower and middle Columbia juveniles, but there would be
20318 corresponding minor adverse effects for chum and lamprey.

20319 **3.5.4.3 Resident Fish**

20320 Region A: MO1 and MO3 would have minor to moderate short-term adverse effects to bull
20321 trout, food webs, varial zones (important for migration), and habitat. MO3 would have riparian
20322 and sturgeon recruitment effects in the Kootenai River as well. MO2 and MO4 would have
20323 moderate to major effects in the same areas. MO4 would also have habitat and access issues in
20324 Lake Pend Oreille.

20325 Region B: Effects from MO1, MO2, and MO4 would range from minor to major adverse effects
20326 to resident fish in Lake Roosevelt stemming from increased entrainment, varial zone effects
20327 (important for migration) and in the river reach, there would be minor reduction in sturgeon
20328 recruitment. MO3 would have minor adverse effects due to potentially increased entrainment,
20329 but would also have a major beneficial effect due to increased recruitment and connectivity for
20330 sturgeon in McNary Reservoir with minor short-term construction-related effects.

20331 Region C: MO1, MO2, and MO4 would have minor to moderate adverse impacts to resident fish
20332 due to warmer summer water temperatures, reduced flows, increased entrainment, or
20333 increased TDG and GBT. MO3 would result in improved connectivity and increased recruitment
20334 for bull trout and white sturgeon and more native fish.

20335 Region D: MO1 would have negligible effects to flows and water temperature; minor adverse
20336 potential sturgeon effects. MO2 and MO3 would have negligible effects to flow and water
20337 temperature. Under MO4, Negligible effects could be expected to flow and water temperature
20338 with minor adverse effects due to increased TDG.

20339 All of these fish have economic, subsistence and culturally significant importance for tribes, and
20340 as shown, effects vary across the study area depending on species. Tribal Interests would be
20341 affected accordingly.

20342 **3.6 VEGETATION, WETLANDS, WILDLIFE, AND FLOODPLAINS**

20343 This section provides analysis for vegetation communities, wetlands, and wildlife, including
20344 special status species, and floodplains. It describes the existing vegetation and wildlife that may
20345 be affected by measures contained in the No Action Alternative and Multiple Objective
20346 Alternatives (MOs), including changes in operations (hydrology) and structures, or dam breach.
20347 Wildlife species are grouped into the following broad categories: birds, mammals, reptiles and
20348 amphibians, and invertebrates. Land cover with vegetation was grouped into the following
20349 broad categories: upland; wetlands-forested; and scrub-shrub, wetlands-emergent herbaceous.
20350 Land cover without vegetation was classified as barren zone. Changes in some key islands were
20351 also analyzed (i.e., Blalock Island, Crescent Island). Wildlife and plant species listed under the
20352 Endangered Species Act and their critical habitat are described separately below in Section
20353 3.6.2.6. Floodplains are discussed in Section 3.6.2.5, Floodplains.

20354 **3.6.1 Area of Analysis**

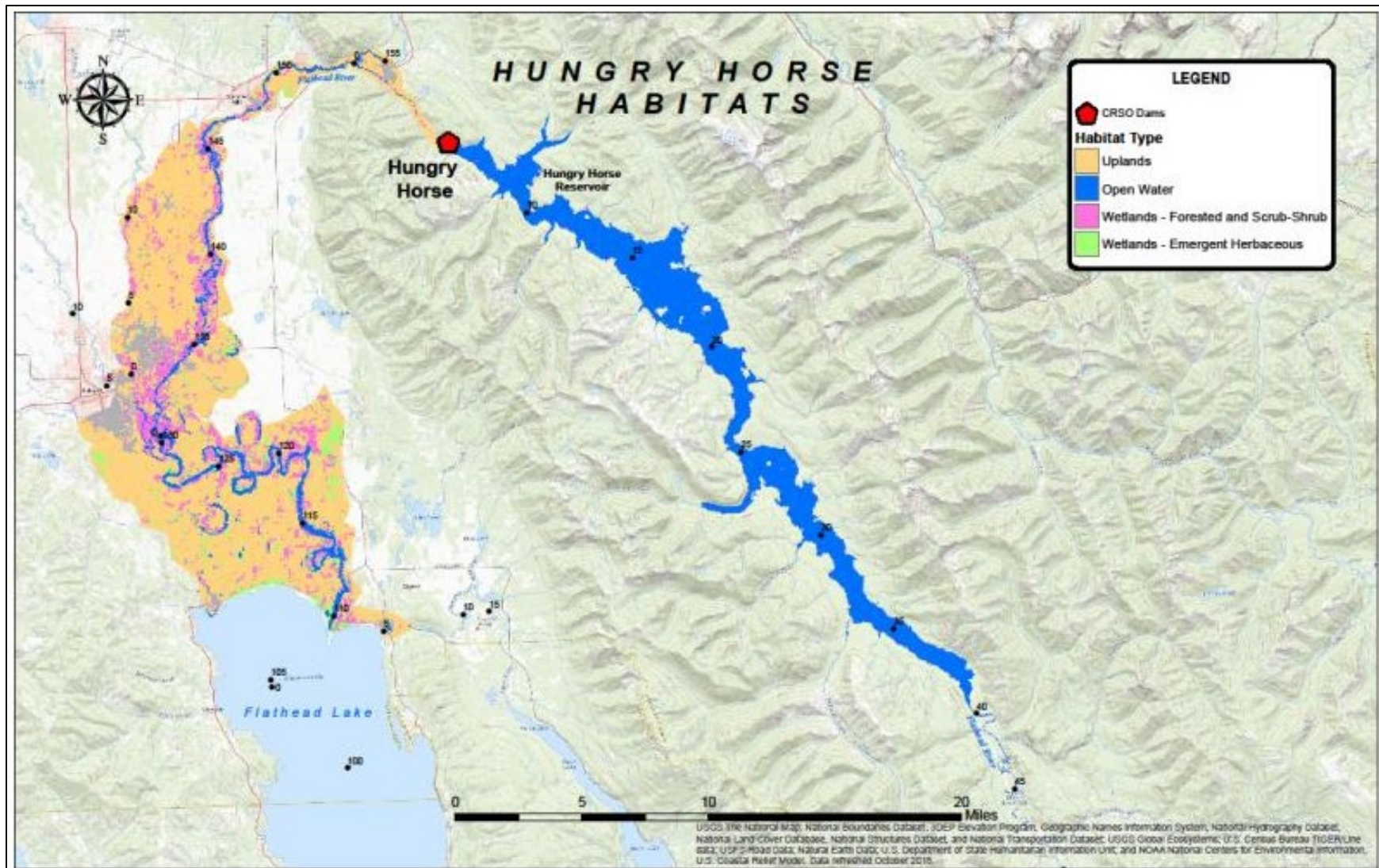
20355 The CRS study area, or area of analysis, for vegetation, wetlands, wildlife, and floodplains
20356 consists of vegetation communities and habitats of the Columbia River Basin currently
20357 influenced by the operations of the 14 Federal projects (the CRS). Affected vegetation
20358 communities both downstream from the dams and the associated reservoirs upstream are
20359 included. The study area extends from the Flathead River, Clearwater River, and the U.S.
20360 portions of the Kootenai River, Pend Oreille River, Clark Fork River, the lower Snake River
20361 (inclusive of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite projects), and the
20362 mainstem Columbia River to the Pacific Ocean and includes the river channels and affected
20363 vegetation and wildlife. A map of the Columbia River Basin is included in Chapter 1 (Figure 1-1).
20364 Many factors including river flows, timing, duration, and water level affect the species
20365 composition and distribution of riparian and upland vegetation and wetlands habitats within
20366 the basin, which in turn influence the wildlife species selected for analysis.

20367 The study area extent is generally based on the extent of the H&H model's study area (Section
20368 3.2 and Appendix B, Part 3, specifically the extents of the hydraulic models used to develop
20369 water surface elevation data across the reaches between dams). These models were developed
20370 to capture inundated areas resulting from a wide range of potential flooding events. See
20371 Appendix A for more information on the H&H modeling tools. For the Libby, Hungry Horse, Lake
20372 Pend Oreille, and Dworshak reservoirs, the study areas were based on reservoir operations and
20373 changes to full pool water surface elevations. These extents were chosen because they capture
20374 changes in water surface elevations that could influence wildlife populations or their habitats as
20375 a result of implementing the operational parameters detailed in each MO. Choosing this extent
20376 also provides consistency with other resources analyzed in this EIS and aligns with modeled
20377 information for the alternatives.

20378 Individual study areas extend upstream from each project to the furthest extent of the
20379 reservoir at its maximum operating water level, or to the U.S.-Canada border. Where project
20380 operations have a meaningful effect on habitat conditions downstream from the project, the

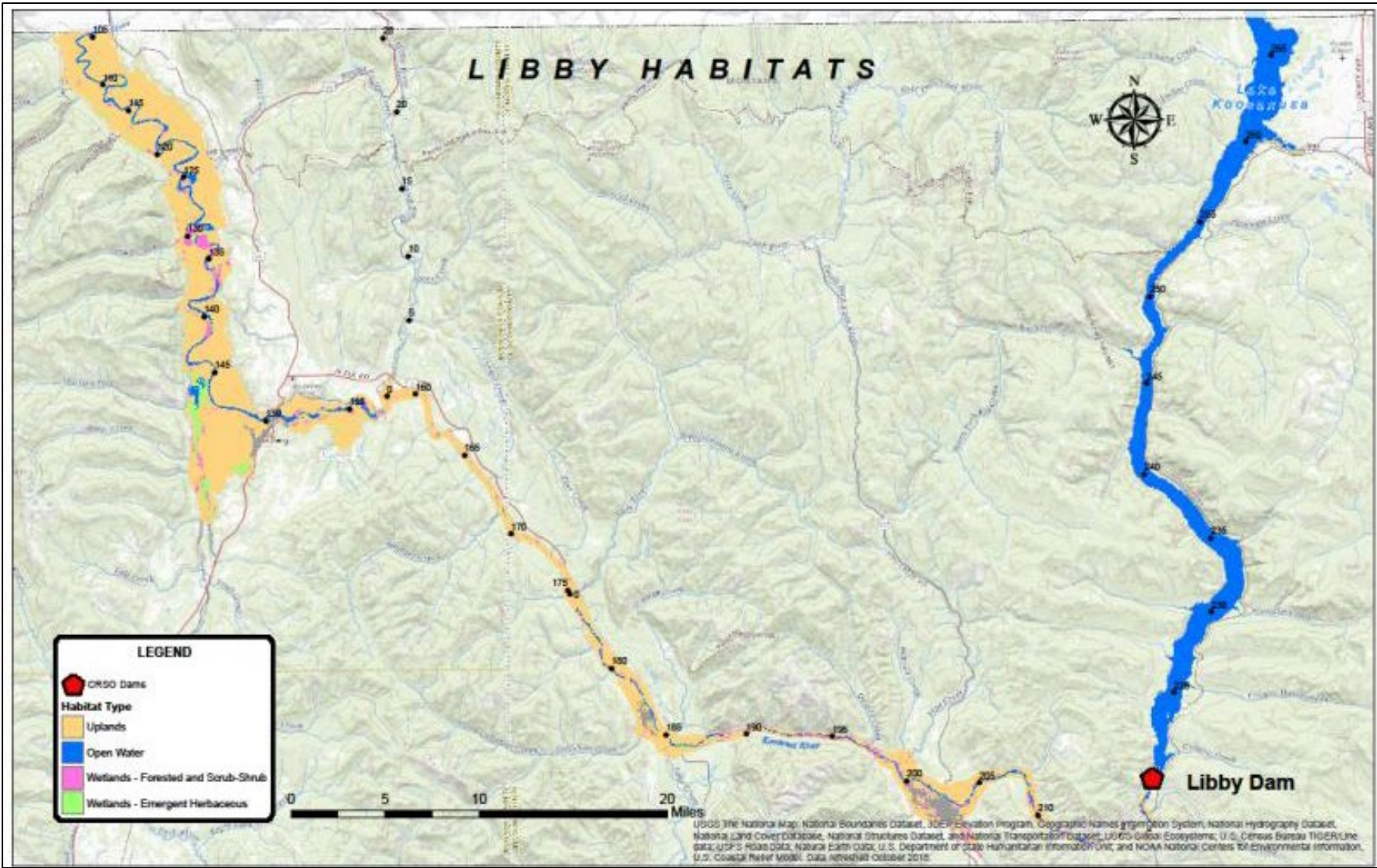
20381 study area extends downstream to the upstream extend of the next downstream project. For
20382 example, for Hungry Horse, the study area includes the Hungry Horse reservoir as well as
20383 approximately 120 miles downstream of Hungry Horse Dam. The project area for John Day, a
20384 run-of-river dam, extends from John Day Dam upstream to the face of McNary Dam. The Dalles
20385 Dam. Figure 3-135 through Figure 3-147 show the projects and their associated study areas.
20386 Appendix F, Vegetation and Wildlife, provides more in-depth reach- and study area-specific
20387 information for vegetation, wetlands, and wildlife, including maps and a discussion of existing
20388 conditions.

20389 For Figure 3-135 through Figure 3-147, much of the area designated as upland in these figures
20390 occupies the natural (pre-development) floodplain but is currently protected from flooding by
20391 levees and reservoir operations (Section 3.9.3). Portions of the areas that are designated
20392 uplands in these figures actually may lie in the active floodplain and wetlands, although these
20393 areas are likely to be infrequently flooded.



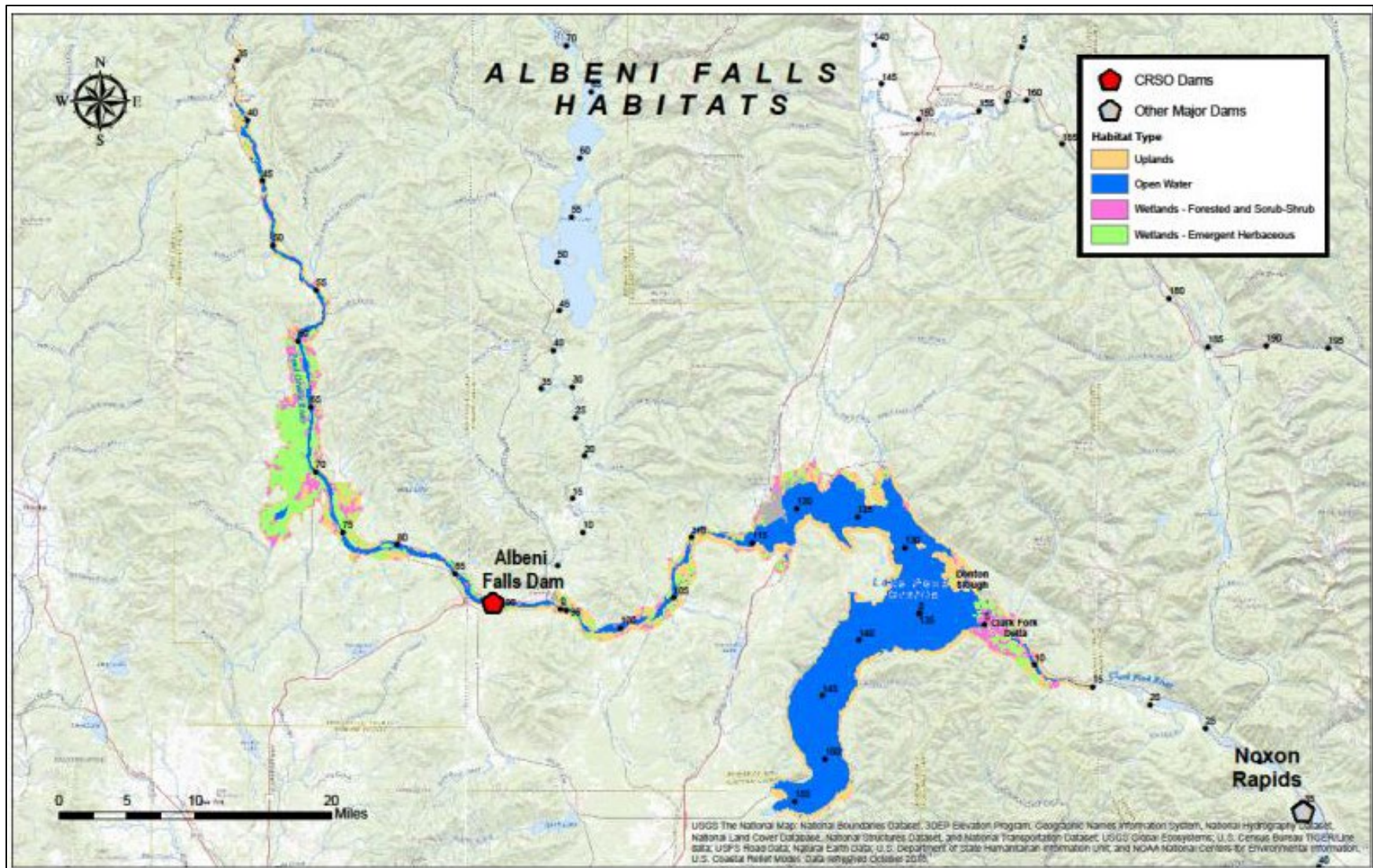
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Figure 3-135. Hungry Horse Study Area for Vegetation, Wetlands, and Wildlife



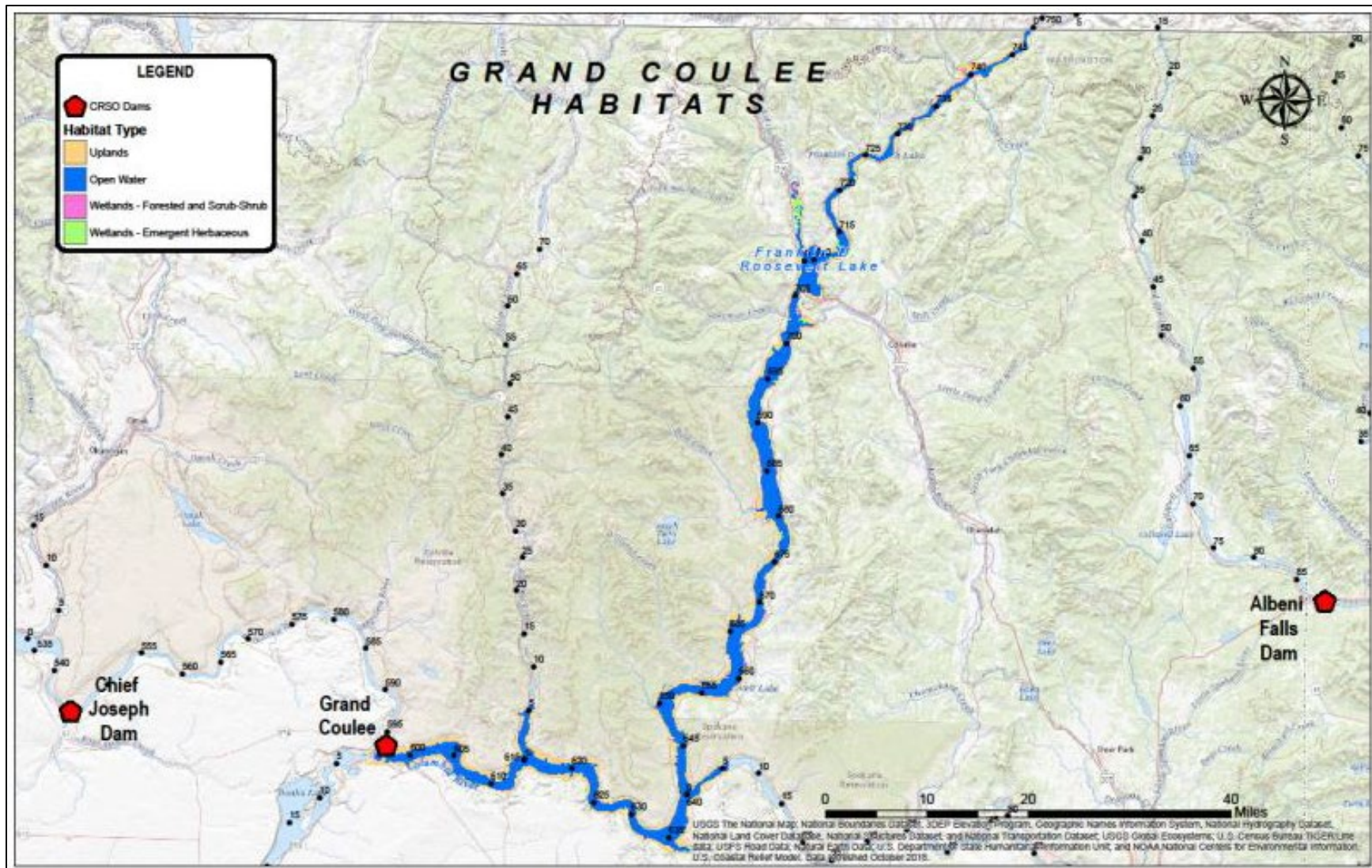
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Figure 3-136. Libby Study Area for Vegetation, Wetlands, and Wildlife



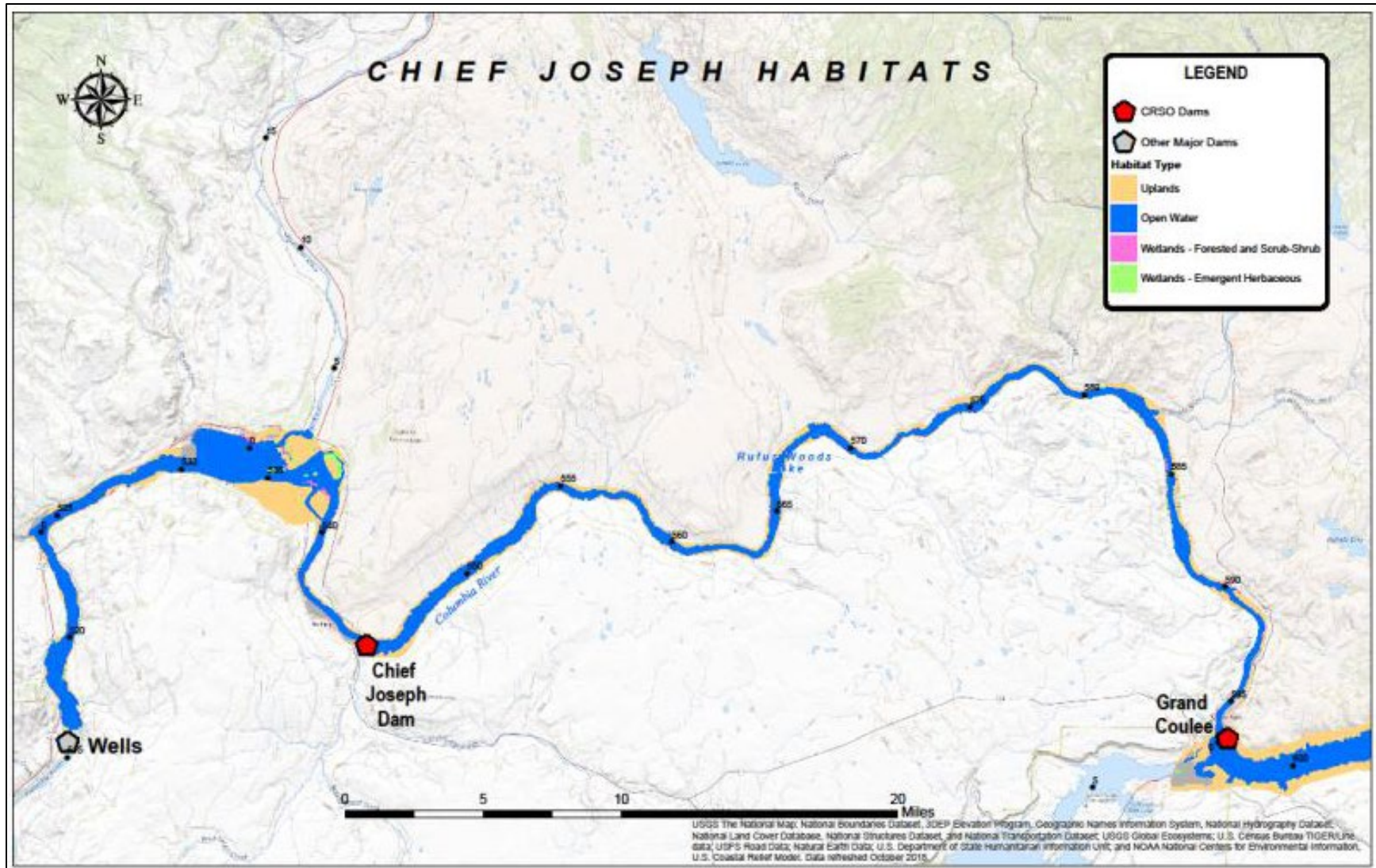
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Figure 3-137. Albeni Falls Study Area for Vegetation, Wetlands, and Wildlife



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Figure 3-138. Grand Coulee Study Area for Vegetation, Wetlands, and Wildlife



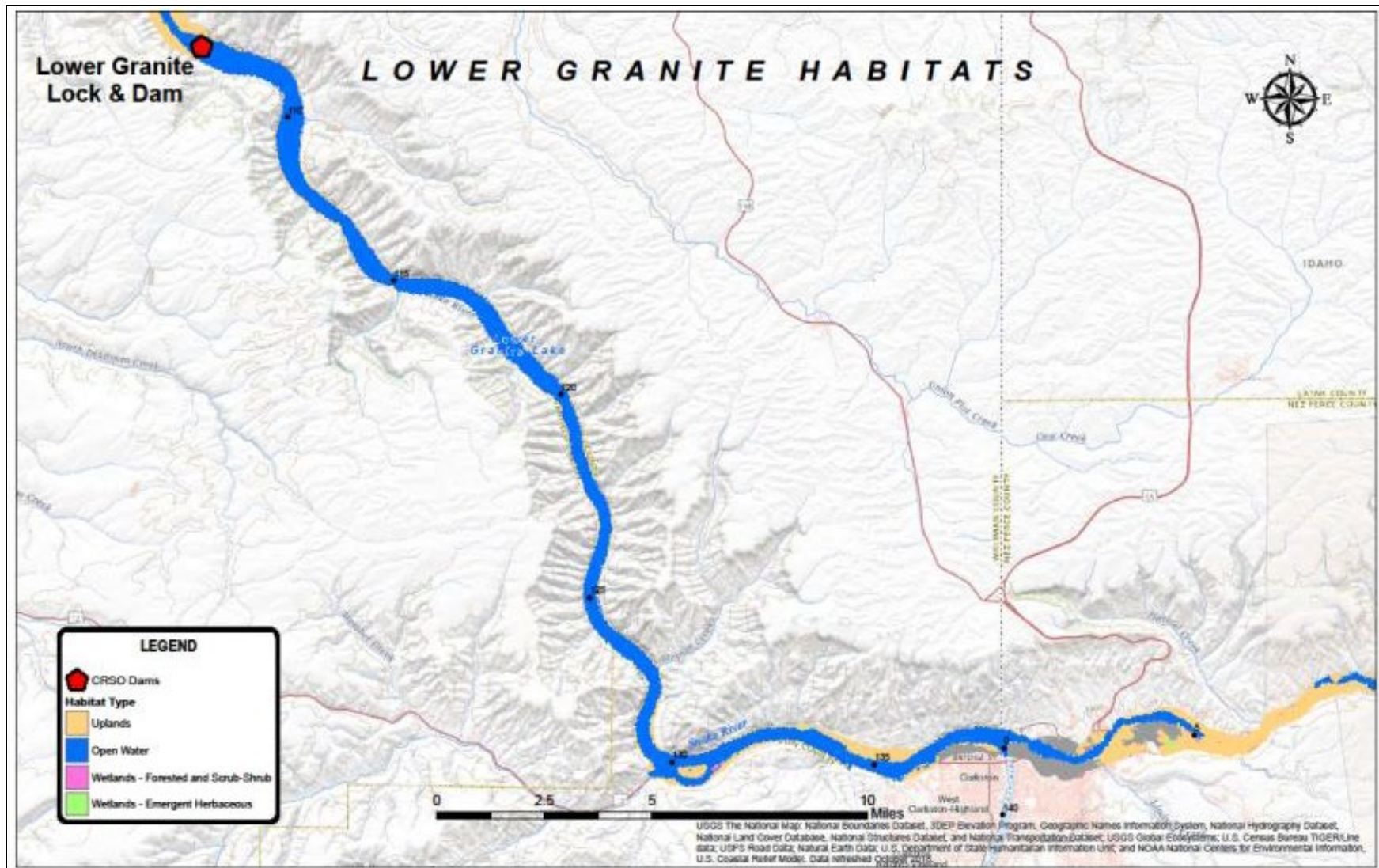
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Figure 3-139. Chief Joseph Study Area for Vegetation, Wetlands, and Wildlife



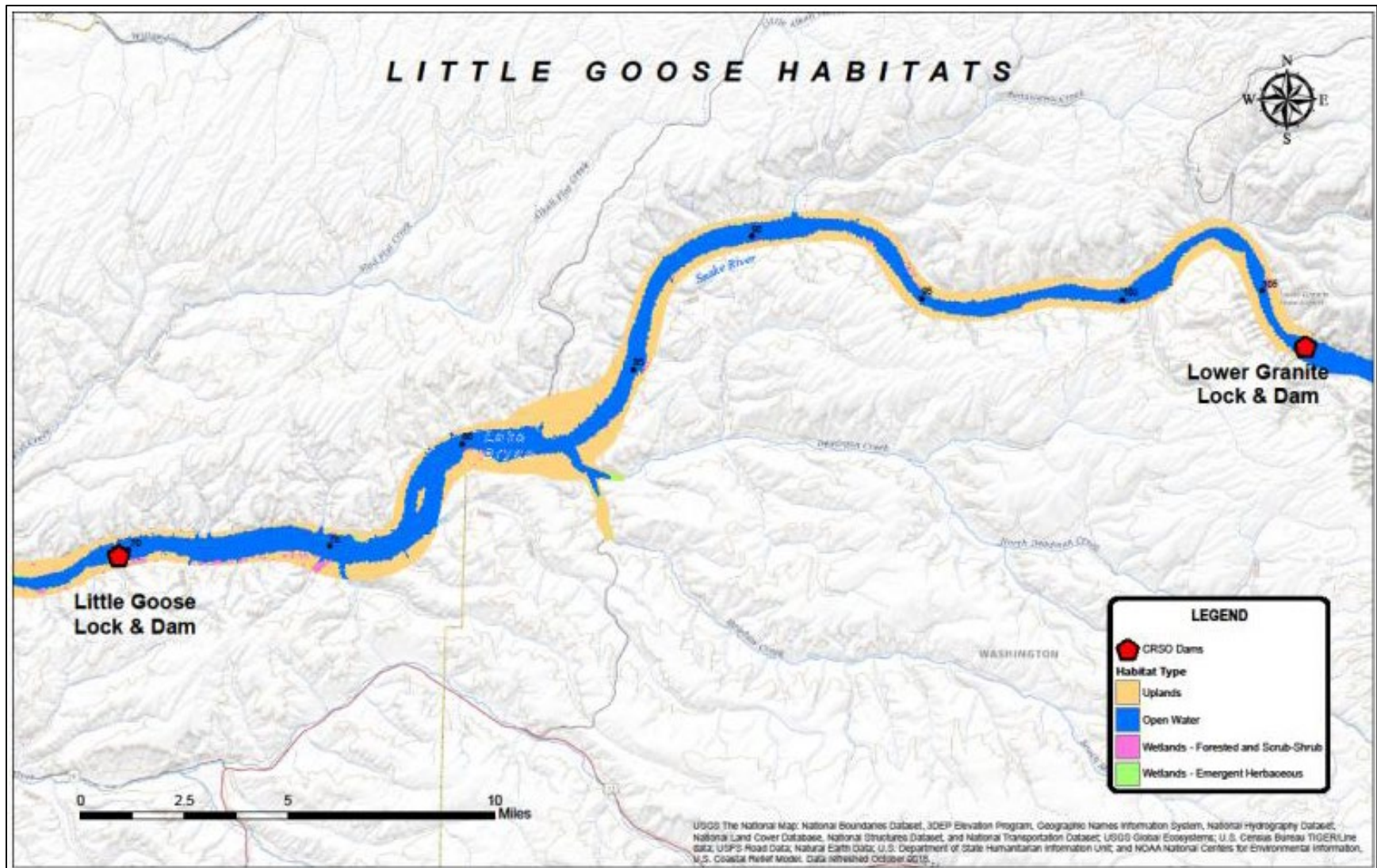
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Figure 3-140. Dworshak Study Area for Vegetation, Wetlands, and Wildlife



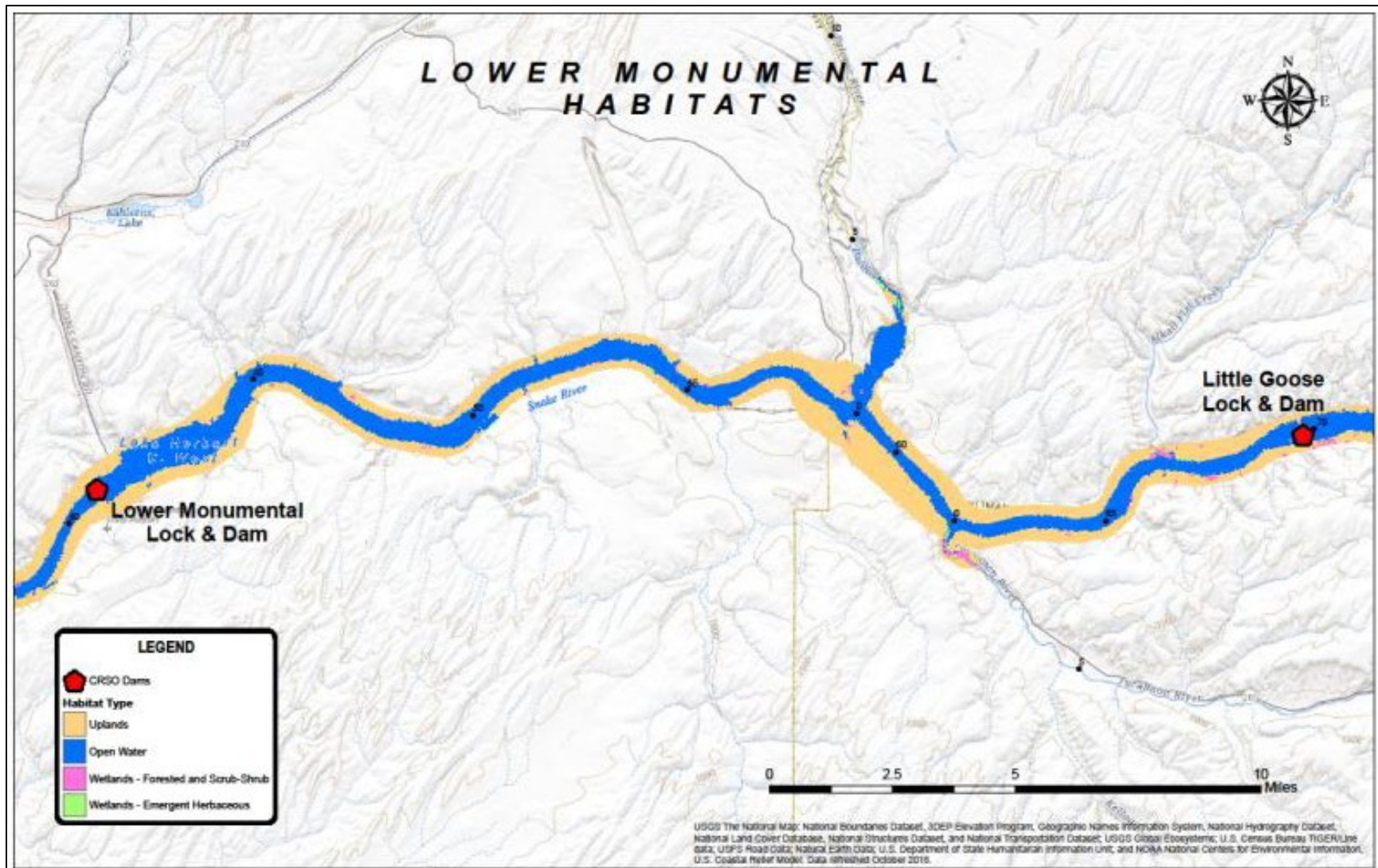
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Figure 3-141. Lower Granite Study Area for Vegetation, Wetlands, and Wildlife



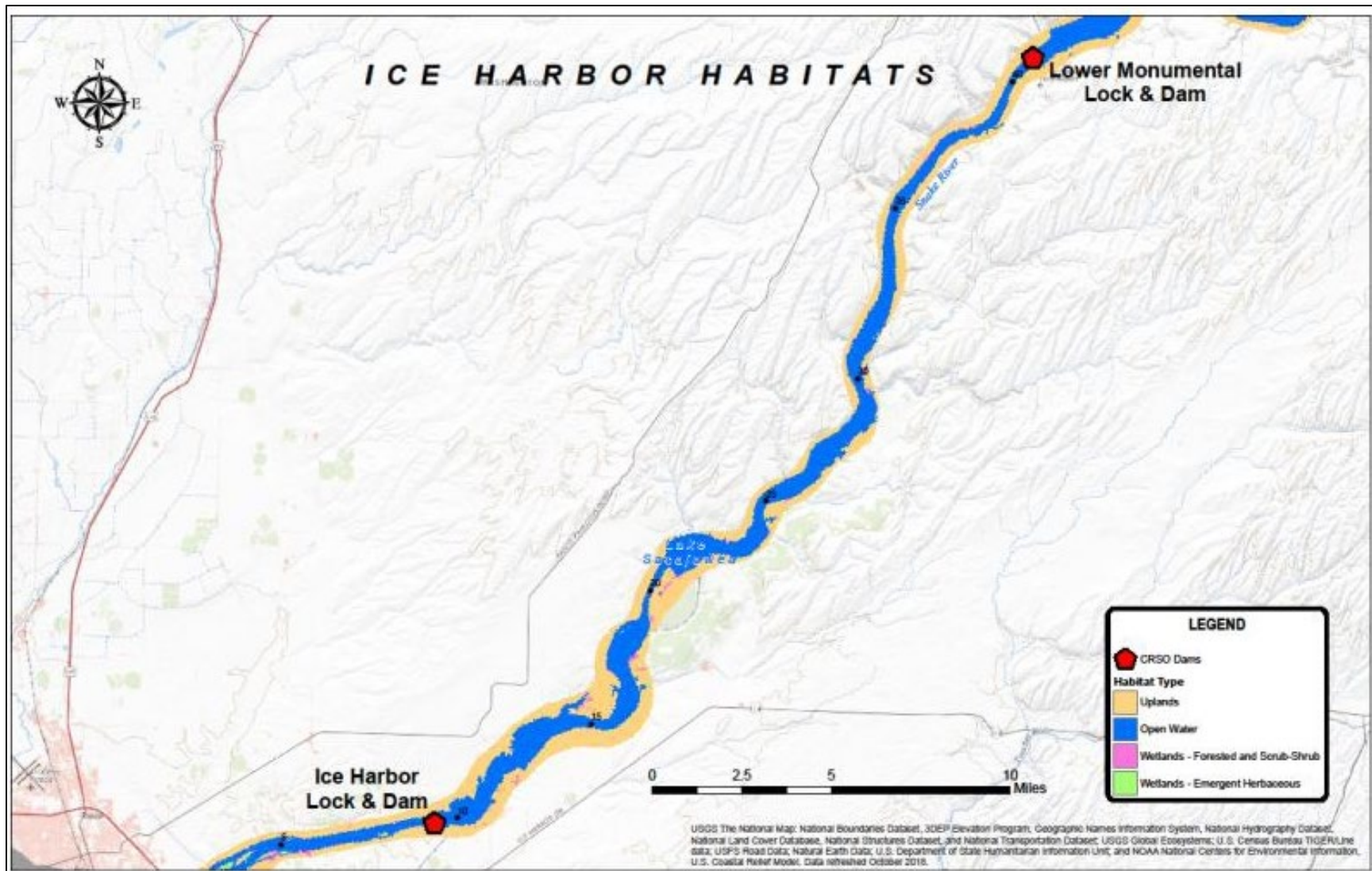
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Figure 3-142. Little Goose Study Area for Vegetation, Wetlands, and Wildlife



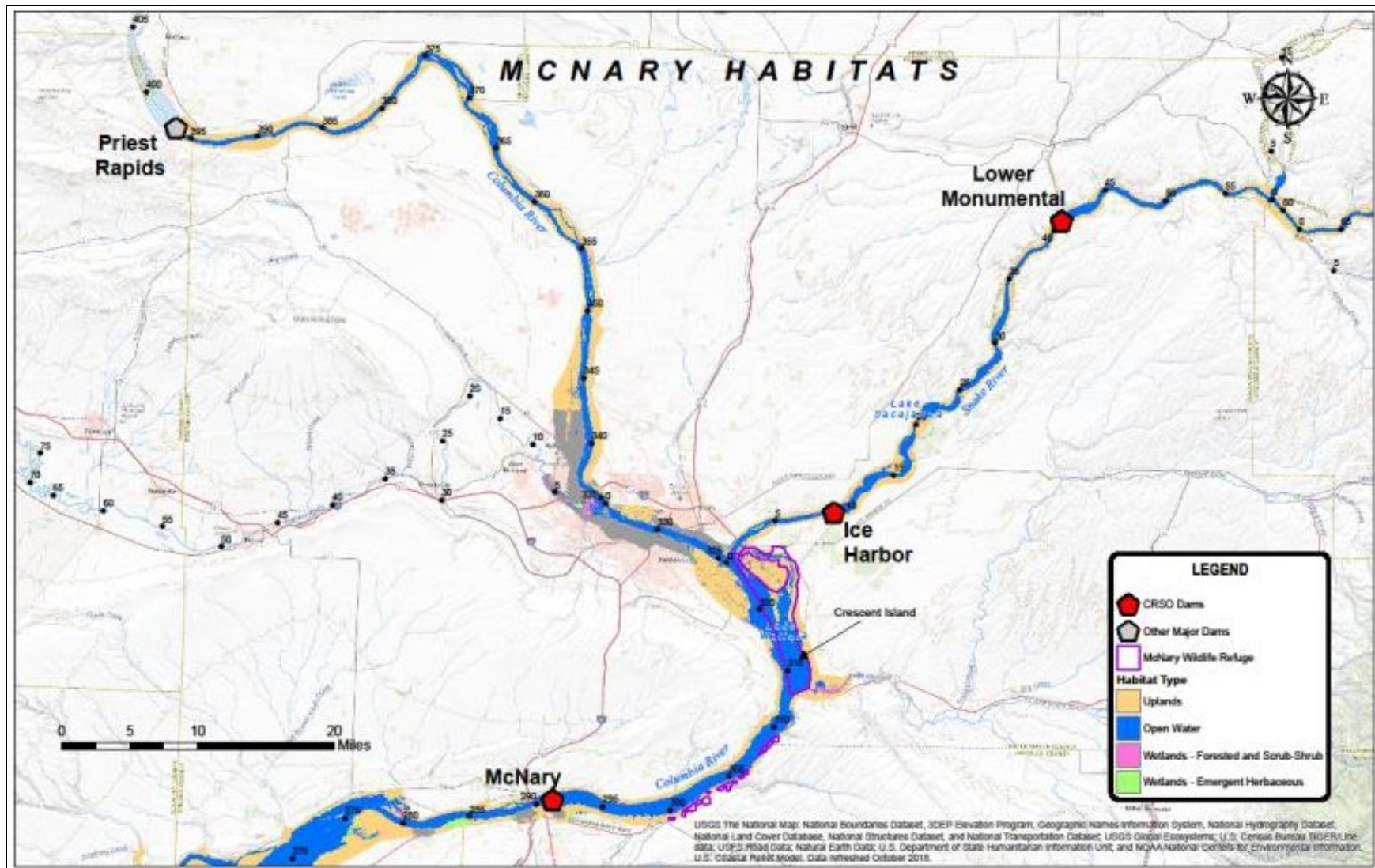
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Figure 3-143. Lower Monumental Study Area for Vegetation, Wetlands, and Wildlife



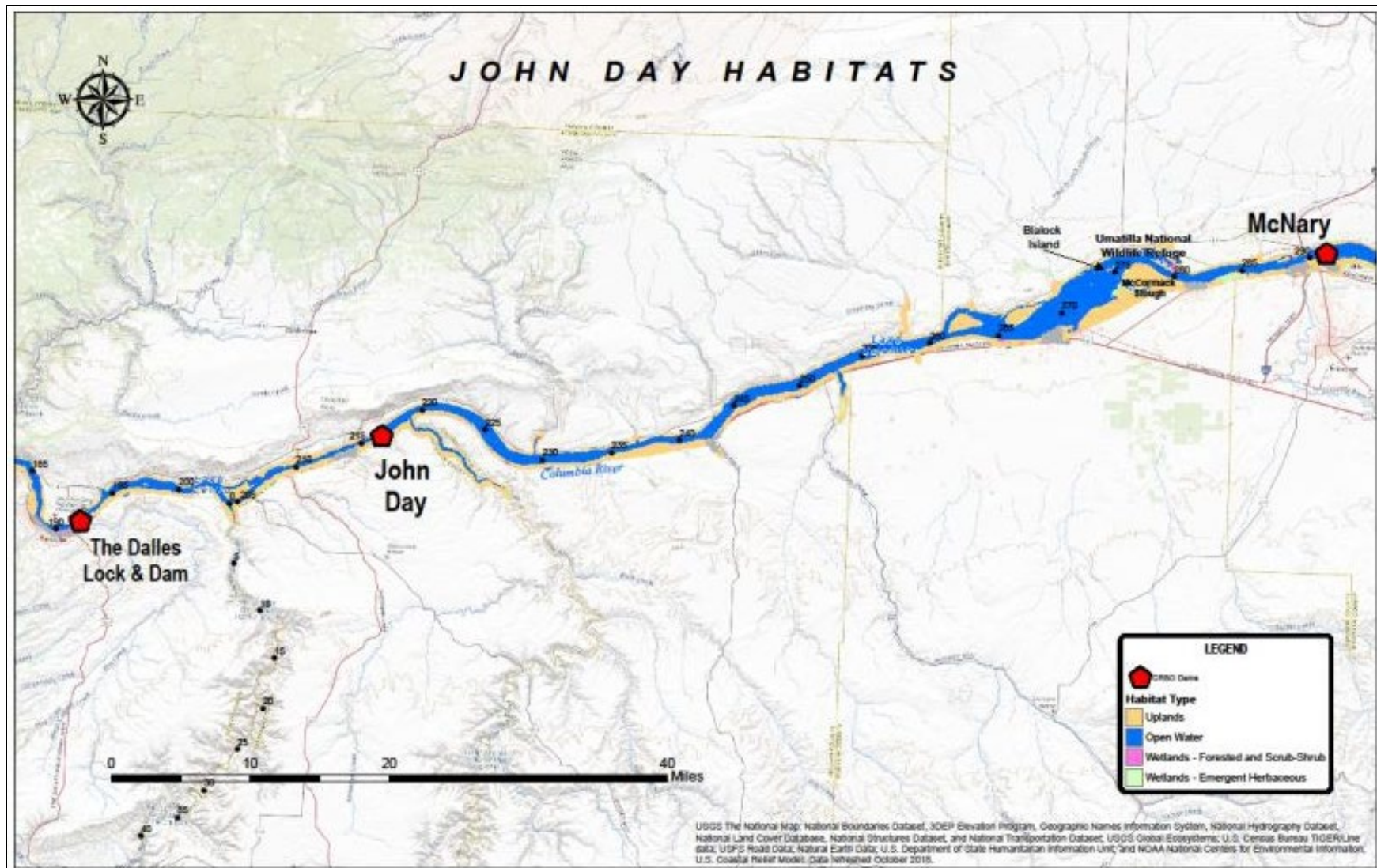
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Figure 3-144. Ice Harbor Study Area for Vegetation, Wetlands, and Wildlife



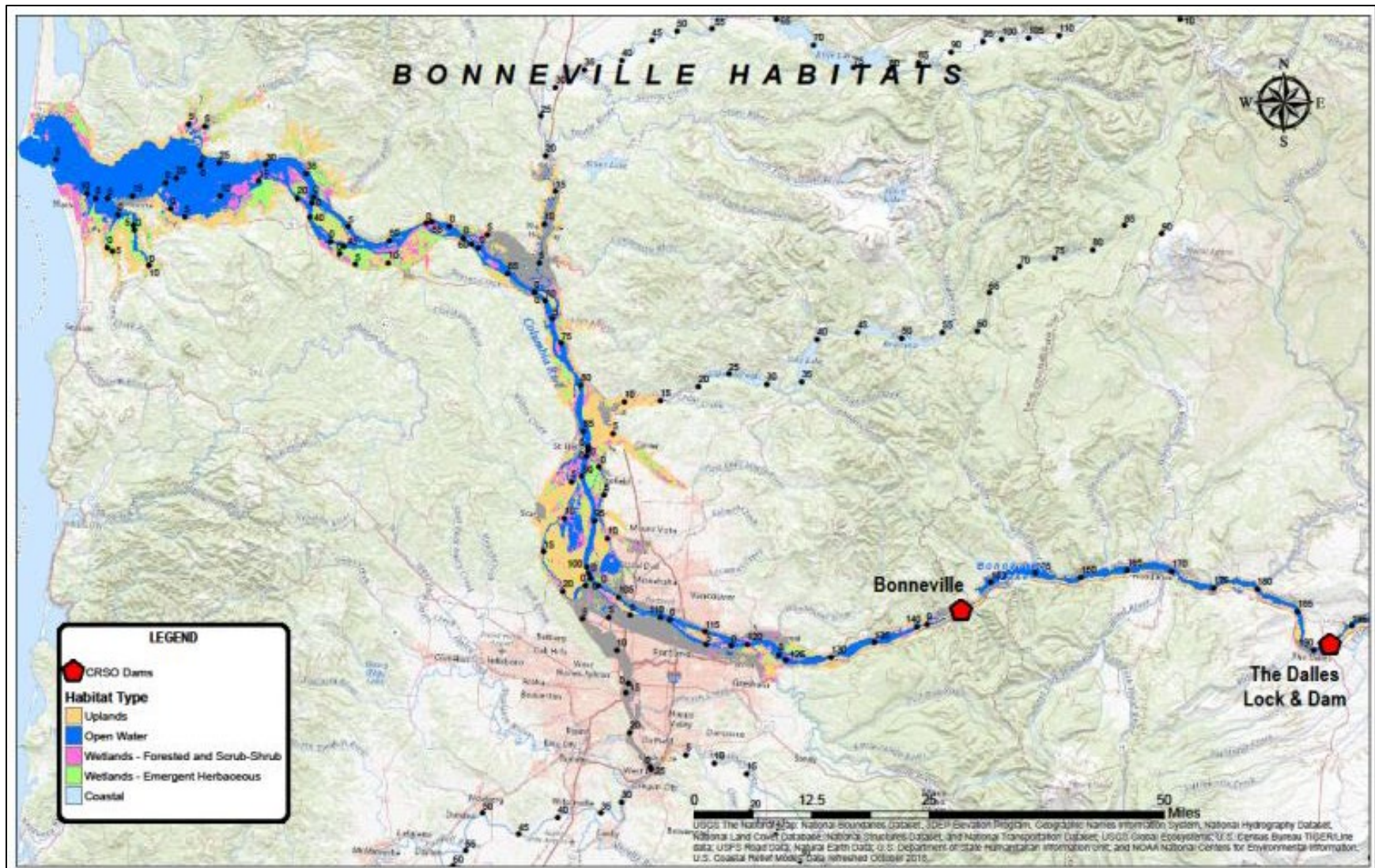
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Figure 3-145. McNary Study Area for Vegetation, Wetlands, and Wildlife



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Figure 3-146. The Dalles and John Day Study Area for Vegetation, Wetlands, and Wildlife



20418
20419

Figure 3-147. Bonneville and Lower Columbia River Study Area for Vegetation, Wetlands, and Wildlife

20420 **3.6.2 Affected Environment**

20421 A diversity of plant communities and wildlife habitats are represented in the basin, including
20422 riparian and wetland habitats, sagebrush (*Artemisia* spp.)-dominated shrub-steppe
20423 communities, mixed coniferous and deciduous forests, moist coniferous forests, grasslands, and
20424 agricultural lands. These vegetation communities are specific to the local topography and
20425 climate ranging from the wet Pacific Ocean estuary located a few feet above sea level to the
20426 high elevation Rocky Mountains, to rich agricultural valleys, to the arid shrub steppe.

20427 **3.6.2.1 Vegetation Communities and Habitat Types**

20428 Land cover types and vegetation communities, or habitat types, are used in this study as proxies
20429 for wildlife habitat. The diverse habitat types (e.g., wetland, upland forest) found throughout
20430 the basin are used by various wildlife species for breeding, nesting, feeding, or sheltering.
20431 Habitat types are differentiated from one another by their structure, form, and species
20432 composition, are shaped by climate patterns, substrate types, and disturbance regimes, and can
20433 be broadly defined by dominant plant species. The habitat types described herein are different
20434 from species-specific habitats, which are unique to individual species and may include multiple
20435 habitat types (e.g., wetlands, forests, marine systems) necessary to complete their lifecycle.

20436 Two primary geographic datasets were used to identify land cover, vegetation, and wildlife
20437 habitat within the CRSO study area: the Northwest Habitat Institute (NWHI) habitat land cover
20438 classifications and the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory
20439 (NWI). These datasets were combined in a geographic information system (GIS) where the
20440 digital NWI data provided the source for all wetland habitats in the CRS study area and the
20441 NWHI dataset was the source for identifying all other habitat types across the CRS study area.
20442 More information on the NWHI and NWI are included in Appendix F, *Vegetation and Wildlife*.

20443 Five habitat types were defined for this study: uplands, water, wetlands, barren zone, and
20444 islands. These habitat types, the focus of this analysis, are those that include habitat elements
20445 that are sensitive to changes in water surface elevation (WSE) and river flows. The NWI and
20446 NWHI datasets do not differentiate or show the barren area around reservoirs, nor do they
20447 delineate islands as such. Rather, the datasets display water up to the full pool elevation and
20448 vegetation coverage on islands. The proposed alternatives may affect WSE and river flows,
20449 potentially resulting in changes in the availability, accessibility, and distribution of these
20450 habitats, affecting a wide variety of wildlife species. NWHI habitats and NWI wetlands were
20451 combined based on types of ecosystems represented and functional groups. Developed and
20452 urban lands were not analyzed in terms of habitat effects as they were considered not to be
20453 sensitive to changes in water surface elevation or river flows under the proposed operations.
20454 Agricultural lands, on the other hand, can provide significant forage and cover (fawning, calving,
20455 nesting, and potential hiding and escape cover) for wildlife. However, they were not delineated
20456 as a separate habitat type nor were they analyzed as a stand-alone vegetation community.

20457 **UPLANDS**

20458 Upland areas consist of a wide variety of vegetation and wildlife habitat types. The term
20459 “upland” typically refers to lands above an alluvial floodplain or river channel. For this analysis,
20460 all lands that are not classified as barren, wetlands (including riparian areas), open water,
20461 coastal, or islands are considered uplands. Uplands in the CRSO study area include coniferous
20462 and hardwood forests, woodlands, grass and scrublands, shrub-steppe, and pasture or
20463 agricultural lands.

20464 At Hungry Horse, Libby, Albeni Falls, Lake Roosevelt (upstream of Grand Coulee Dam), and
20465 Dworshak Dams, the upland areas are dominated by coniferous forests including ponderosa
20466 pine on the warm, dry exposed slopes and a mix including ponderosa pine, western larch,
20467 Douglas-fir, lodgepole pine, western hemlock, and western red cedar on wetter slopes, at lower
20468 elevations, and near the water’s edge. Deciduous tree species such as black cottonwood,
20469 willow, and red alder are also found in areas near water. Understory shrubs include western
20470 serviceberry, bitterbrush, ocean spray, mallow-leaf ninebark, and snowberry.

20471 From Grand Coulee Dam down through The Dalles Dam and lower Snake River Projects, upland
20472 areas are dominated by shrub-steppe vegetation. The shrub component is dominated by big
20473 sagebrush, rabbitbrush, serviceberry, currant, and antelope bitterbrush while Idaho fescue,
20474 Indian ricegrass, Sandberg bluegrass, Thurber's needlegrass, needle-and-thread, sand dropseed,
20475 bluebunch wheatgrass, and bottlebrush squirrel tail make up the primary native grass species.
20476 Common forbs include arrowleaf balsamroot, yarrow, various buckwheats, blanket flower,
20477 various parsleys, and lupine species.

20478 Upland habitats in the Lake Bonneville study area are diverse and range between warm, dry
20479 shrub-steppe to wet, cool forests near the Cascade Range. Mountain hemlock forests transition
20480 to drier ponderosa pine and mixed Douglas fir and grand fir forests and then shift to Oregon
20481 white oak woodlands and grasslands at the lowest elevations. Deciduous trees include red
20482 alder, big-leaf maple, and smaller canopy trees such as cascara buckthorn. Understory shrubs
20483 and forbs in upland habitats may include salal, Oregon grape species, and swordfern.

20484 **WATER**

20485 The water cover type includes rivers and streams, lakes, reservoirs, bays, and estuaries. In the
20486 CRS study area, the water cover type (also referred to as open water) is composed primarily of
20487 the Columbia River and its major tributaries, and storage project reservoirs. Water is a cover
20488 type that is used by terrestrial and aquatic wildlife. Many types of wildlife species use open
20489 water as primary foraging habitats, migration corridors, or temporary refuge from predators.

20490 Aquatic vegetation that is submerged for its entire lifecycle provides important food resources
20491 and shelter for several classes of vertebrates. The aquatic vegetation species commonly found
20492 in the CRSO study area are pondweed, parrotweed, duckweed, the invasive *Elodea*, knotweed,
20493 and milfoil. Aquatic stalked diatom known as Didymo has become established at a

20494 nuisance/noxious density in the Kootenai River downstream of Libby Dam and in localized areas
20495 in the Flathead River below Hungry Horse Dam.

20496 **WETLANDS**

20497 Wetland habitats are important ecological features providing a multitude of benefits to the
20498 human environment and a unique variety of fish, wildlife, and plant species that are adapted to
20499 survive at least part of their life cycle in aquatic environments. Wetlands can be classified based
20500 on a dominant vegetation (e.g., evergreen or deciduous) or exposed substrate type (e.g.,
20501 cobble, gravel, bedrock). While local hydrologic conditions typically vary over time, plant
20502 species and soil characteristics tend to reflect the long-term hydrologic conditions of a site and
20503 can help identify wetland types when local hydrology is absent. These habitats are usually a
20504 transitional area between upland habitats and aquatic habitats. Because wetlands, including
20505 riparian habitats, are dependent on the duration of seasonal inundation, these habitats are
20506 sensitive to changes in project operations influenced by river flows and precipitation patterns.
20507 For this EIS, two types of wetlands are described below: forested and scrub-shrub, and
20508 emergent herbaceous. Newly exposed transitional areas that could develop into vegetated
20509 wetlands over time are referred to in this EIS as mudflats and could be composed of silty,
20510 clayey, or rock material. The length of time that the sediment is exposed would determine if
20511 vegetation would establish in these unvegetated sediments.

20512 Riparian zones are transitional areas between flowing and non-flowing bodies of water and the
20513 upland terrestrial habitat. Riparian zones are frequently inundated and can contain wetlands.
20514 There is no generally agreed upon classification system for riparian vegetation, although a
20515 number of systems have been proposed and are in use by individual Federal, state, and local
20516 agencies. For the purposes of this EIS, riparian habitat is incorporated into the Wetlands –
20517 Forested and Scrub-Shrub section below.

20518 **Wetlands – Forested and Scrub-Shrub**

20519 Forested and scrub-shrub wetlands (riparian habitat) provide important feeding, sheltering, and
20520 breeding or nesting habitat for wildlife. The vegetation stabilizes river and stream channel
20521 banks and reduces erosion. Along rivers and streams, this vegetation provides a shade canopy
20522 over stream channels to reduce temperatures. In addition, this vegetation slows surface water
20523 and filters out sediments to improve water quality. Woody wetlands support a high diversity of
20524 wildlife.

20525 Throughout the CRS study area forested and scrub-shrub wetlands adjacent to rivers are
20526 dominated by deciduous shrub and deciduous tree cover types with a dense understory of
20527 grasses, forbs, and shrubs. Cottonwood, aspen, alders, chokecherry, and willows, with some
20528 conifers, are common in the forested and scrub-shrub wetlands. Native shrub and undergrowth
20529 species typically include red-osier dogwood, mountain alder, gooseberry, various roses,
20530 common snowberry, various willows, and Douglas spirea. Himalayan blackberry, a non-native
20531 species, is a common shrub. Herbaceous species may include native forbs, grasses, and sedges,

20532 as well as invasive and non-native species such as reed canary grass, Western false indigo,
20533 flowering rush, yellow flag iris, purple loosestrife, and salt cedar.

20534 **Wetlands – Emergent Herbaceous**

20535 Emergent wetlands are limited in extent throughout the CRSO study area. They are restricted
20536 by the steep shorelines, seasonal drawdowns, and shorter-term fluctuations that also
20537 influence other habitat types. The emergent wetlands occur along the shoreline primarily in
20538 embayments, the mouths of small streams, and in the confluences of larger tributary streams
20539 and rivers.

20540 Common plants present in emergent wetlands include cattails, horsetail, bulrush, and sedges.
20541 Invasive species such as common reed, reed canary grass, pondweed, parrotweed, duckweed,
20542 invasive *Elodea*, knotweed, milfoil, flowering rush, yellow flag iris, purple loosestrife, salt cedar,
20543 Japanese knotweed, and western false indigo become a dominant species in some areas.

20544 **BARREN (BARREN ZONE)**

20545 Within the barren cover type, this study focuses on the barren zone within a project reservoir.
20546 This is shoreline habitat surrounding reservoirs, which is characterized by having no permanent
20547 vegetation. When reservoirs are full of water, the barren zone is not present, or present only as
20548 a minor fringe around the perimeter of the lake. Plants do not generally grow in the barren
20549 area, and the areas do not provide good habitat for wildlife. They are discussed herein because
20550 barren areas do present challenges and opportunities for wildlife and can influence migration
20551 and predation. As projects are operated and reservoirs are drawn down, the land previously
20552 underwater surrounding the lake is exposed. Generally, the storage projects such as Hungry
20553 Horse, Libby, Albeni Falls, Grand Coulee, and Dworshak have a wider barren zone during
20554 drawdown than run-of-river projects.

20555 **ISLANDS**

20556 In the CRS study area, islands occur both in reservoirs and rivers. Individual islands or groups of
20557 islands may contain one of the cover types identified above, or may contain a mosaic of these
20558 cover types. Depending on their size, elevation, and available habitat types, islands can support
20559 a wide variety of plant and wildlife species.

20560 In the CRS study area, there are hundreds of islands found both in reservoirs and downstream
20561 of the projects, which provide crucial habitat for wildlife species. For example, the Blalock
20562 Islands are low-elevation bedrock islands, which are part of the Umatilla National Wildlife
20563 Refuge in Lake Umatilla. The Blalock Islands are notable because they provide breeding habitat
20564 for colonial nesting waterbirds like Caspian terns, American white pelicans, and several gull
20565 species. Other islands, like Puget, Whites, and Tenasillahe Islands downriver from Bonneville
20566 Dam, cover large areas and provide a diverse array of mixed habitat types supporting numerous
20567 wildlife species and populations. Tenasillahe Island is notable because it provides complex
20568 forested wetlands and oak savannahs, which support the Endangered Species Act (ESA)-listed

20569 threatened Columbian white-tailed deer. Other islands support large breeding colonies of
20570 waterbirds, including Miller Sands Island and East Sand Island near the mouth of the Columbia
20571 River. Several thousand Caspian terns and double-crested cormorants nest at East Sand Island,
20572 along with smaller populations of Brandt's cormorant and ring-billed gulls. Several hundred
20573 American white pelicans nest at Miller Sands Island and Rice Island in the lower river.

20574 **3.6.2.2 Introduced and Invasive Species**

20575 Non-native and invasive plants are currently damaging biological diversity and ecosystem
20576 integrity across the Columbia Basin and within the study area. Invasive plants cause
20577 displacement of native plants; reduction of habitat and forage for wildlife; changes to plant
20578 composition in sensitive areas such as wetlands; loss of sensitive species; impaired water
20579 quality; reduced soil productivity and increased erosion; and changes in the intensity and
20580 frequency of fires. Invasive plants spread through the air and water, on vehicles, animals, and
20581 humans. All lands are at risk of invasive plants. A few of the most common invasive plants in the
20582 study area are cheatgrass (*Bromus tectorum*), flowering rush (*Butomus umbellatus*), reed
20583 canary grass (*Phalaris arundinacea*), and Eurasian watermilfoil (*Myriophyllum spicatum*).

20584 Throughout the study area, the co-lead agencies are involved with cooperative weed
20585 management efforts, invasive species prevention and eradication, and vegetation treatments.
20586 For example, on wildlife mitigation properties funded through Bonneville's F&W Program,
20587 project partners are replanting grasslands and other habitats with native species in order to
20588 outcompete non-native weeds as well as experimenting with prescriptive livestock grazing and
20589 other tools.

20590 Populations of invasive plant species are expected to continue to occur and potentially increase
20591 throughout the study area, consistent with current trends. The alternatives proposed herein
20592 would not change or impact the co-lead agencies' ability to continue with these efforts or affect
20593 their ability to conduct invasive species management efforts at projects or participate in
20594 cooperative weed management efforts. Effects from invasive species to vegetation, wetlands,
20595 and wildlife are discussed only when alternatives are anticipated to cause a measurable change
20596 in the quantity or distribution of invasive species and their subsequent impact on the ecological
20597 function of wildlife habitat. The alternatives may impact vegetation communities and increase
20598 or expose bare ground. Where this may occur, and where weeds are a concern, impacts are
20599 discussed.

20600 Aquatic species are of particular concern, since they spread rapidly and can quickly alter the
20601 function of an ecosystem. Quagga mussels (*Dreissena bugensis*) and zebra mussels (*Dreissena*
20602 *polymorpha*) are invasive, fingernail-sized mollusks that are native to fresh waters in Eurasia.
20603 They spread by drifting in water currents and attaching to watercraft. They negatively impact
20604 ecosystems in many ways causing harm to the environment, the economy, or to human health.
20605 They filter out algae that native species need for food and they attach to and incapacitate
20606 native mussels. The threat of zebra mussels at hydropower facilities relates to the species
20607 ability to quickly colonize underwater infrastructure such as screens, trash racks, and water
20608 delivery systems, which has the potential to render fish passage and protection facilities

20609 inoperable. The Columbia River Basin is the last river system free of these mussels in the United
20610 States (NWER 2015).

20611 Strict boating inspection and widespread educational materials and training are essential to
20612 keeping these species out of the system. Idaho, Montana, Oregon, and Washington all have
20613 established rapid response plans for these mussels (Western Regional Panel on Aquatic
20614 Nuisance Species 2010; Idaho Department of Agriculture 2012; WDFW et al. 2014; Center of
20615 Lakes and Reservoirs-Portland State University et al. 2013). The states are also currently in the
20616 process of developing a cost-share agreement with the Corps, under Section 104 of the River
20617 and Harbor Act of 1958 (as amended), for development of a rapid response plan.

20618 Additional invasive fish species are listed in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates,*
20619 *and Fish*. If these species are present in the CRS study area, they may require control measures.
20620 Species that have not yet become established but have the potential to be introduced are the
20621 Asian carp, emerald ash borer, European chafer, longhorned beetle, northern snakehead fish,
20622 and overbite clam.

20623 **3.6.2.3 National Wildlife Refuges and Other Federally Managed Wildlife Lands**

20624 Throughout the CRS study area, there are numerous national wildlife refuges and other
20625 federally managed lands for the benefit of wildlife. Of these, the Kootenai, McNary, and
20626 Umatilla National Wildlife Refuges (NWRs) and the Corps-managed Habitat Management Units
20627 (HMUs) along the lower Snake River may be impacted by one or more of the alternatives
20628 presented in this draft EIS, therefore the discussion is limited to these areas.

20629 The Kootenai NWR near the Selkirk Mountains of northern Idaho was established as a migratory
20630 waterfowl refuge. The refuge provides habitat for over 220 bird species including bald eagle,
20631 mallard, northern pintail, and green-winged teal. Forty-five species of mammals use the refuge
20632 habitat, including moose, elk, deer, bear, and otter (USFWS 2017). This refuge contains 2,774
20633 acres of wetlands, meadows, riparian forests, and cultivated agricultural fields, which provides
20634 habitat for over 220 bird species and 45 mammal species (USFWS 2017). The seasonal wetlands
20635 are drained in spring and summer to promote emergent vegetation for waterfowl.

20636 There are five special wildlife management areas in the Hungry Horse Project study area: the
20637 Owen Sowerwine Natural Area, Flathead River Wildlife Habitat Protection Areas, Foy's Bend
20638 Fisheries Conservation Area, and North Shore Waterfowl Production Area. These areas are
20639 mainly restored wetlands and planted riparian areas and are important bird areas that are
20640 managed to maintain or improve habitat conditions for fish and wildlife.

20641 McNary NWR covers over 15,000 acres along the left bank of Lake Wallula from the confluence
20642 of the Columbia River with the Snake River to the mouth of the Walla Walla River, and
20643 downstream into Oregon. The refuge includes sloughs, ponds, streams, islands, forested and
20644 herbaceous wetlands, and upland shrub-steppe and cliff-talus habitats. It serves as an anchor
20645 for biodiversity in the middle Columbia Basin (Corps 2018).

20646 The Umatilla NWR provides wildlife habitat along both shorelines of Lake Umatilla, where the
20647 refuge is composed of a multitude of different habitat types supporting a wide diversity of
20648 wildlife. The refuge includes many islands, which provide breeding/nesting/roosting habitat for
20649 colonial (mostly fish-eating) nesting birds as well as habitat supporting a variety of waterfowl
20650 species.

20651 Within the lower Snake River Projects study area, HMUs were developed as mitigation for
20652 effects to wildlife resources during dam construction and operations. A total of 62 HMUs are
20653 scattered along the Snake River from Ice Harbor Dam to the upper extent of the Lower Granite
20654 Reservoir. There are approximately 107,382 acres of HMUs within the lower Snake River
20655 Projects study area. These HMUs include uplands, wetlands—forested and scrub-shrub,
20656 wetlands—emergent herbaceous, and islands land cover types.

20657 There are several refuges downstream of Bonneville Dam that span and support multiple
20658 habitat types, vegetation communities, and salinity gradients. Pierce, Franz Lake, Steigerwald
20659 Lake, and Ridgefield Lake NWR are managed as the Ridgefield Wildlife Complex. This collection
20660 of refuges supports a broad mosaic of wetlands, riparian forests, sloughs, wet meadows, and
20661 meadows, all of which support a high diversity of plants and wildlife. The Julia Butler Hansen
20662 Refuge for Columbian white-tailed deer and the Lewis and Clark NWR are managed as part of
20663 the Willapa Complex and also contain a diverse array of habitats and habitat features to
20664 support fish and wildlife in the region. The Lewis and Clark NWR encompasses 20 islands and
20665 stretches over 27 miles of the Columbia River. Additional information about refuges and refuge
20666 complexes are available in Appendix F, Vegetation and Wildlife.

20667 Where impacts are anticipated to these wildlife areas, they are discussed below under the
20668 appropriate alternative and region. If an alternative is not anticipated to result in impacts to
20669 wildlife refuges or management areas, or there are no refuges or wildlife management areas in
20670 a given region that would be affected by an alternative, no narrative is provided in the analysis
20671 under Section 3.6.3.

20672 **3.6.2.4 Wildlife**

20673 The CRS study area provides important habitat for a diversity of wildlife species. Hundreds of
20674 wildlife species use the Columbia River mainstem and tributaries for breeding, nesting, feeding,
20675 and sheltering, including amphibians, reptiles, birds, and mammals. Wildlife species common to
20676 habitat found throughout the CRS study area are briefly discussed in this section. Species were
20677 grouped into the following broad categories: birds, mammals, reptiles and amphibians, and
20678 invertebrates. The information in this section was gathered from published and unpublished
20679 reports and discussions with local professional wildlife biologists. Additional information
20680 regarding wildlife associated with the different reaches can be found in Appendix F, *Vegetation
20681 and Wildlife*.

20682 Note that special status species are discussed in a subsection below.

20683 **BIRDS**

20684 The Columbia River and its tributaries provide habitat for many migrating and resident birds.
20685 The CRS study area includes several important stopover areas for migrating birds as well as
20686 many important bird areas ranging from the north shore of Flathead Lake in Montana to along
20687 the Pacific Ocean. The CRS study area is within the Pacific Flyway and a portion of the Central
20688 Flyway and thus provides crucial resting and foraging habitat for millions of migrating birds, as
20689 well as a variety of primary habitat and niche habitat for resident and breeding birds. Species
20690 associated with wetlands, riparian areas, open water, arid lands, and forests are abundant
20691 throughout the CRS study area.

20692 In the upper basin reaches of the CRS study area such as Libby, Hungry Horse, Albeni Falls, and
20693 Dworshak, forested areas provide habitat for raptors and species such as mountain chickadee,
20694 woodpecker, bluebird, crossbill, and pine siskin. The habitats surrounding the Grand Coulee
20695 Dam, the lower Snake River Projects, and down to The Dalles provide arid, canyon, sagebrush
20696 steppe, and dry forest habitats for sage-grouse, northern harrier, cliff swallow, and horned lark.
20697 The lower reaches of the Columbia support American white pelican, tern, great blue heron,
20698 plover, and sandpiper. Bald and golden eagles nest throughout the CRS study area. Reservoirs
20699 provide feeding areas for these large birds and other raptors. They most commonly nest in
20700 large cottonwoods, snags, pine trees, or other evergreen trees or on cliffsides.

20701 Common raptor species include goshawk, Swainson's hawk, Northern harrier, ferruginous
20702 hawk, Cooper's hawk, red-tailed hawk, merlin, osprey, American kestrel, prairie falcon, and
20703 Peregrine falcon. Barred owl, Western screech owl, flammulated owl, short-eared owl,
20704 Northern saw-whet owl, great horned owl, and burrowing owl are found in the CRS study area
20705 as well. Owls nest in or on riparian trees and upland forests, snags, hillsides, and open
20706 woodlands and hunt small birds and mammals in forested areas, open grasslands, and
20707 agricultural lands. Riparian cottonwood areas and nearby evergreen forests are also important
20708 nesting habitats for other raptors, including bald eagle, osprey, falcons, and hawks, where birds
20709 hunt and forage in wetlands, shallow-water habitats, and the deeper waters of the Columbia
20710 River for fish and other prey.

20711 Shorebirds and waterfowl are abundant throughout the CRS study area during all seasons, but
20712 particularly during migration periods when hundreds of species can be found at important bird
20713 areas, such as the north shore of Flathead Lake and the Columbia, McNary, and Umatilla NWRs.
20714 Many large waterbirds, including tern, cormorant, and gull, prey on juvenile fish, including
20715 salmonids out-migrating to the ocean. These birds are frequently found nesting and foraging
20716 near projects in the middle and lower Columbia River, as well as in the Columbia River Estuary.
20717 Shorebirds and other waterbird species also frequent dams and mudflats surrounding
20718 reservoirs for foraging and some nesting. Shorebirds and waterbirds commonly found on
20719 mudflats include various grebes and gulls, sandpiper, plover, American coot, killdeer, common
20720 snipe, greater and lesser yellowlegs, long-billed curlew, American avocet, great blue heron,
20721 American white pelican, long-billed dowitcher, greater egret, and American bittern. Over 30
20722 waterfowl species use open water, marshes, deltas, and riparian areas associated with the

20723 rivers and reservoirs. Waterfowl nest in marshes and adjacent riparian or upland habitats.
20724 Emergent vegetation, submerged vegetation, and shoreline habitats are also important for
20725 rearing activities and for food resources. The most numerous and diverse species of waterfowls
20726 are migrants, many of which are also year-round residents. Common species include mallard,
20727 wood duck, bufflehead, harlequin duck, pintail, American widgeon, teal, gadwall, goldeneye,
20728 grebe, scaup, American coot, common merganser, tundra and trumpeter swans, cackling goose,
20729 Barrow's goldeneye, and Canada goose. Many of the reaches support large flocks of waterfowl,
20730 and serve as major stopovers in the spring and fall for tens of thousands of birds. Some of the
20731 highest concentrations of waterfowl in the Pacific Northwest are found in the CRS study area at
20732 numerous locations. Wetland habitats, which can be rare in arid areas, provide high-quality
20733 forage and cover for overwintering waterfowl. Island habitats provide protected nesting
20734 habitats as well.

20735 The CRS study area provides diverse habitat for passerines (also known as perching or
20736 songbirds). The upper basin reaches have mixed conifer habitats which support species such as
20737 the mountain chickadee, swallow, wren, bluebird, finch, flycatcher, red-breasted nuthatch,
20738 American robin, hermit thrush, warbling vireo, red-eyed vireo, fox sparrow, pine siskin, and
20739 dark-eyed junco. Riparian areas, marshes, and islands provide habitat for warbling vireo, yellow
20740 warbler, common yellowthroat, thrush, swallow, bobolink, red-winged blackbird, marsh wren,
20741 song sparrow, white-crowned sparrow, and numerous others. Horned lark, western
20742 meadowlark, loggerhead shrike, sage thrasher, and sage sparrow are representative passerine
20743 species found in sage-steppe upland habitat. Colonies of cliff swallow and bank swallow are
20744 found throughout the CRS study area along the Columbia River and tributaries. While not
20745 classified as passerines, numerous woodpecker species have been observed in the CRS study
20746 area, including Lewis's woodpecker, hairy woodpecker, downy woodpecker, Northern flicker,
20747 pileated woodpecker, red-naped sapsucker.

20748 Gallinaceous and Columbine birds, or ground-feeding birds, in the CRS study area include
20749 several species of grouse, wild turkey, ring-necked pheasant, Eurasian collared dove, mourning
20750 dove, Hungarian partridge, California quail, and band-tailed pigeon. In higher elevations, the
20751 ruffed grouse and blue grouse are common in riparian areas, while spruce grouse are common
20752 in coniferous forests along valley walls. Agricultural lands near rivers support ring-necked
20753 pheasant and mourning dove. Chukar, Hungarian partridge, collared dove, mourning dove, ring-
20754 necked pheasant, and California quail eat a variety of seeds, agricultural plants (e.g., wheat,
20755 oats, and corn) and insects. Pheasant and quail are found most commonly near agricultural
20756 lands and generally do not venture far into shrub-steppe areas. Chukar use a wide variety of
20757 habitats including riparian, shrublands, talus areas (accumulated rocks at the base of slopes),
20758 and uplands. The breeding and wintering range for Eurasian collared dove has increased
20759 westward in recent years as the species rapidly moves into new habitats following introduction
20760 into Florida in the 1980s.

20761 **MAMMALS**

20762 Common mammals found within some or all the CRS study area include coyote, fox, mule and
20763 white-tailed deer, elk, black bear, mountain goat, raccoon, beaver, rabbit, weasel, skunk,
20764 porcupine, chipmunk, squirrel, vole, shrew, bushy-tailed woodrat, kangaroo rat, deer mouse,
20765 and the house mouse. The smaller mammals can be found throughout various types of
20766 vegetation communities in the CRS study area. In higher elevations, such as near Albeni Falls,
20767 Libby, and Hungry Horse projects, less common species are snowshoe hare, marten, Canada
20768 lynx, grizzly bear, wolverine, bighorn sheep, fisher, and moose. Mule deer, white-tailed deer,
20769 and elk are the most common species managed for hunting in the CRS study area. Herds of big
20770 game species are common in all reaches and rely on the diversity of habitats to provide food
20771 and cover for their survival and successful reproduction.

20772 Bats are found throughout the CRS study area and likely forage on insects over and near the
20773 reservoirs and rivers. Documented species of bats are Townsend's big-eared bat, pallid, fringed
20774 myotis, long-eared myotis, long-legged myotis, small-footed myotis, canyon bat, California bat,
20775 hoary bat, silver-haired bat, big-brown bat, and Yuma myotis. These bats forage on stream
20776 insects such as midges, caddisflies, and mayflies and can roost up to 2 miles from the river and
20777 reservoir in various habitat types such as forests, arid grassland, shrubs, trees, and rocky areas.
20778 Most of the bat species use a wide range of locations, including caves, mines, trees, buildings,
20779 bridges, dams, and rock crevices as roost sites. White-nose syndrome, a disease caused by a
20780 fungus that affects hibernating bats, is not currently known in the study area, but it has been
20781 detected in Washington State. White-nose syndrome is considered one of the worst wildlife
20782 diseases in modern times and has decimated populations in the eastern United States and
20783 Canada.

20784 Aquatic mammals in the CRS study area include beaver, muskrat, river otter, and mink, whose
20785 population densities are highly variable across the CRS study area. Beaver prefer riparian
20786 habitats and marshes with willow, poplar, or other soft wood trees, near permanent water
20787 sources. Muskrat, otter, and mink use the rivers, sloughs, lakes, reservoirs and streamside
20788 habitats. The barren areas associated with storage reservoirs and rivers limit the habitat
20789 availability for these and many other species.

20790 **AMPHIBIANS AND REPTILES**

20791 The variety of aquatic, riparian, and upland habitats supports several species of amphibians and
20792 reptiles but in numbers notably less than in warmer regions of the United States. Most
20793 amphibian and reptile species depend on shallow-water areas, streambanks, and reservoir
20794 edges, and favor submerged or seasonal emergent vegetation. Amphibian and reptile species
20795 use these areas during portions of the year because they provide an abundance of food, cover,
20796 and water. Amphibians are present in many of the wet habitats, especially wetland and riparian
20797 habitats, and include Pacific giant salamander, tiger salamander, long-toed salamander, tree
20798 frog, Columbia spotted frog, leopard frog, Pacific chorus frog, tailed frog, Western toad, and the
20799 non-native invasive American bullfrog. Bullfrogs are predators for other amphibians and
20800 reptiles and can decimate or extirpate local native populations. Many amphibians are closely

20801 tied to wet habitats like rivers and sloughs while reptiles can be found from upland coniferous
20802 forests to the mats of emergent plant bed in river sloughs. Columbia spotted frog, a Federal ESA
20803 candidate species, and Coeur D'Alene salamander, listed as a species of special concern in
20804 Idaho and Montana, may be present within the study area. Western toad and Northern leopard
20805 frog breed in off-channel pools and forested woodlands along slow-moving rivers in Montana,
20806 Idaho, and along the shore of Lake Roosevelt from early May until late June. Tadpoles are
20807 general present from late May to early September.

20808 Reptiles include painted turtle, garter snakes (common and western terrestrial), prairie and
20809 western rattlesnakes, bull snake, racer, gopher snake, western skink, rubber boa, short-horned
20810 lizard, sagebrush lizard, Western fence lizard, and Northern alligator lizard. Reptiles occur in a
20811 wide variety of habitats including grasslands and coniferous forests.

20812 **3.6.2.5 Floodplains**

20813 Floodplains are the low-lying, relatively flat areas adjoining water bodies that become partially
20814 or completely inundated during periods of high flow and rapid surface runoff. Floodplains are
20815 generally distinguished from adjacent uplands by a noticeable change in the ground slope.
20816 Floodplains include low-elevation areas that are regularly flooded (e.g., every two or three
20817 years, on average) and extend to areas at higher elevations that may be rarely flooded. Lower
20818 magnitude floods that occur more frequently can be important in the functioning of natural
20819 floodplains. Relatively undisturbed floodplains, or those that are restored to a more natural
20820 state, can provide a variety of benefits including natural flood and erosion control, water
20821 quality maintenance, and groundwater recharge; maintenance of biodiversity, fish and wildlife
20822 habitat, and ecosystem services; and societal benefits such as agricultural production, aesthetic
20823 values, and recreational opportunities (Federal Emergency Management Agency [FEMA] 1994).

20824 Flood risk management focuses on reducing the effects of high-hazard, low-frequency floods.
20825 For the purpose of flood risk management, the floodplain area is defined by its probability of
20826 being inundated. The base (100-year) floodplain is the inundated area resulting from a flood
20827 with an annual exceedance probability (AEP) of 1 percent. That is, there is a 1 percent chance
20828 that the base floodplain will be inundated during any given year. The critical action (500-year)
20829 floodplain has a 0.2 percent chance of being inundated during any given year (AEP of 0.2
20830 percent). As described in Section 3.9, *Flood Risk Management*, Columbia River Basin floodplains
20831 have been extensively modified during the last century for flood risk management (e.g., levees).
20832 These modifications substantially affected the occurrence and functioning of the natural
20833 floodplains along the river. In addition, projects supporting navigation, hydropower, and
20834 agricultural production have impacted benefits associated with relatively undisturbed
20835 floodplains. The effects of past floodplain modifications on other resource areas are discussed
20836 elsewhere in this chapter: Section 3.3.2 describes effects on sedimentation and river
20837 morphology; Section 3.4.2 describes effects on water quality; and Section 3.5.1 describes
20838 effects on fish habitats.

20839 The existing floodplains within the Columbia River Basin occupy the open water and wetland
20840 areas shown in the figures in Section 3.6.1, *Area of Analysis*. Much of the area designated as

20841 upland in these figures occupies the natural (pre-development) floodplain, but is currently
 20842 protected from flooding by levees and reservoir operations (Section 3.9.3). Because of the way
 20843 uplands are defined here, portions of the areas that are designated uplands in the Section 3.6.1
 20844 figures actually may lie in the active floodplain and wetlands, although these areas are likely to
 20845 be infrequently flooded.

20846 **3.6.2.6 Special Status Species**

20847 The following list of threatened, endangered, and sensitive species are species that are listed or
 20848 candidates for listing under the ESA of 1973, as amended, and/or protected under the Marine
 20849 Mammal Protection Act (MMPA) of 1972, as amended. The list covers species that may occur
 20850 within the CRS study area or be impacted by any of the alternatives (Table 3-101). The USFWS
 20851 Environmental Conservation Online System database and USFWS field office websites were
 20852 accessed to determine if species should be considered given their range and habitat
 20853 preferences. Appendix F, Vegetation and Wildlife, includes more information regarding
 20854 migratory bird and marine mammal special status species.

20855 Special Status Species were identified using the USFWS Environmental Conservation Online
 20856 System (ECOS) database, USFWS field office websites, and previous biological opinions. Species
 20857 evaluated in previous biological opinions that are outside of the influence of the CRS operations
 20858 were not considered for further assessment. These include the woodland caribou, Northern
 20859 Idaho ground squirrel, water howelia, Spalding’s catchfly, White Bluffs bladderpod, gray wolf,
 20860 and Macfarlane’s four o’clock. The effects to these species will not change as a result of CRS.
 20861 Additional terrestrial species that are were not carried forward through the assessment include
 20862 the Canada lynx, pygmy rabbit, red tree vole, marbled murrelet, northern spotted owl, short-
 20863 tailed albatross, Nelson’s checker mallow, and Oregon spotted frog. These species are
 20864 evaluated, and CRS was determined to have “no effect” as they are spatially separated from the
 20865 CRS. For more information on these species, refer to Appendix F.

20866 **Table 3-101. Candidate, Endangered, and Threatened Species in the Vicinity of the Columbia**
 20867 **River System Operations Study Area**

Species, Critical Habitat, and Status				State				Species Carried Forward Through Analysis
Species	ESA Status	Critical Habitat	MMPA	ID	MT	OR	WA	
Mammals								
Canada Lynx	T	Yes	N/A	X	X	X	X	–
Gray Wolf	E	No	N/A	–	–	–	X	–
Grizzly Bear	T	No	N/A	X	X	–	X	X
Columbia Basin Pygmy Rabbit	E	No	N/A	–	–	–	X	–
Columbian White-Tailed Deer	T	No	N/A	–	–	X	X	X
Red Tree Vole	C	N/A	N/A	–	–	X	–	–

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Species, Critical Habitat, and Status				State				Species Carried Forward Through Analysis
Species	ESA Status	Critical Habitat	MMPA	ID	MT	OR	WA	
Birds								
Marbled Murrelet	T	Yes	N/A	-	-	X	X	-
Northern Spotted Owl	T	Yes	N/A	-	-	X	X	-
Short-Tailed Albatross	E	No	N/A	-	-	X	X	-
Streaked Horned Lark	T	No	N/A	-	-	X	X	X
Western Snowy Plover	T	Yes	N/A	-	-	X	X	-
Bald Eagle	N/A	N/A	N/A	X	X	X	X	X
Golden Eagle	N/A	N/A	N/A	X	X	X	X	X
Western Yellow-Billed Cuckoo	T	No	N/A	X	X	X	X	X
Amphibians								
Oregon Spotted Frog	T	Yes	N/A	-	-	X	-	-
Plants								
Ute Ladies'-Tresses	T	No	N/A	X	X	-	X	X
Water Howelia	T	No	N/A	X	-	X	X	-
Nelson's Checker-Mallow	T	No	N/A	-	-	X	X	-
Spalding's Catchfly	T	No	N/A	X	X	X	X	-
White Bluffs Bladderpod	T	Yes	N/A	-	-	-	X	-
Marine Mammals								
Southern Resident Killer Whale DPS	E	Yes	Yes	-	-	X	X	X
California Sea Lion	N/A	N/A	Yes	-	-	X	X	X
Steller Sea Lion	N/A	N/A	Yes	-	-	X	X	X

20868 Note: C: candidate; E: endangered; T: threatened; N/A = not applicable.

20869 **GRIZZLY BEAR**

20870 The grizzly bear is listed as threatened throughout the conterminous United States, except in
20871 the Bitterroot recovery area where it is listed as an experimental population. The current range
20872 for grizzly bear overlaps with areas in the CRSO study area in Montana near Libby and Hungry
20873 Horse Reservoirs. Habitat use by grizzly bear within the Columbia River Basin varies throughout
20874 the year and may include open-canopied upland forests, meadows, riparian and riverine areas,
20875 and shrub lands. The Northern Cascades Ecosystem (NCE) in north-central Washington and
20876 south-central British Columbia has the most at-risk population in the United States today. The
20877 grizzly bear recovery zone within the NCE encompasses 9,800 square miles, includes all of the
20878 North Cascades National Park, and most of the Mount Baker-Snoqualmie, Wenatchee, and
20879 Okanogan National Forests (Servheen 1997), and extends to the Columbia River. Despite the
20880 NCE encompassing, beyond the recovery zone, an additional 3,800 square miles across the U.S.-
20881 Canada border and providing rugged, remote habitat, the grizzly bear population in Washington
20882 is estimated to be fewer than 20 animals. The population is under review to determine a
20883 potential up-listing from threatened to endangered status. The eastern border of the NCE
20884 parallels State Route 97 and nearly reaches Chief Joseph Dam.

20885 The Northern Continental Divide Ecosystem (NCDE) in northwestern Montana includes Glacier
20886 National Park, and the Bob Marshall Wilderness Complex, including the Flathead, Kootenai,
20887 Helena-Lewis and Clark, and Lolo National Forests, contained within 8,900 square miles. The
20888 population within this ecosystem is approximately 1,000 animals and continues to grow. This
20889 ecosystem encompasses the Hungry Horse Dam study area including the Hungry Horse
20890 Reservoir and all forks of the Flathead River.

20891 The Cabinet-Yaak Ecosystem (CYE) is located in northern Idaho and northwest Montana and has
20892 an estimated 50 grizzly bears. The Kootenai River, with the Cabinet Mountains to the south and
20893 the Yaak River area to the north, bisects the CYE. Most of the 2,600 square miles are within the
20894 Kootenai and Panhandle National Forests (USFWS 2017a). This ecosystem encompasses Libby
20895 dam study area, northern area of Lake Pend Oreille, and the Kootenai River.

20896 **COLUMBIAN WHITE-TAILED DEER**

20897 The Columbia River Distinct Population Segment (DPS) of the Columbian white-tailed deer has
20898 maintained its threatened status since listing on March 11, 1967 (32 FR 4001). The Columbia
20899 River population occurs along the lower Columbia River in Oregon and Washington from
20900 Wallace Island at River Mile (RM) 50 downstream to Karlson Island at RM 32. There are four
20901 main subpopulations (Washington mainland, Tenasillahe Island, Puget Island, Wallace Island–
20902 Westport) of Columbian white-tailed deer and one minor one (Karlson Island) that are
20903 geographically separated by a main river channel or patches of unfavorable habitat. Julia Butler
20904 Hansen National Wildlife Refuge, located in the Columbia River Estuary, was established by
20905 USFWS for the recovery and maintenance of the Columbian white-tailed deer.

20906 The islands and bottomlands within an 18-mile stretch of the lower Columbia River contain
20907 most of the Columbian white-tailed deer range. The Columbian white-tailed deer are restricted
20908 to the flatlands, which have an elevation of about 10 feet above sea level. Vegetation cover
20909 preferred by Columbian white-tailed deer includes forested communities with plant heights of
20910 at least 2 feet. Studies completed in the 1970s identified the primary plant communities used
20911 by Columbian white-tailed deer as park-forest, open canopy forest, sparse rush, and dense
20912 thistle (Suring 1974), and some subpopulations used “tidal spruce” communities (Davison
20913 1979).

20914 **STREAKED HORNED LARK**

20915 The streaked horned lark was listed as threatened in October 2013. The streaked horned lark is
20916 endemic to the Pacific Northwest and is a subspecies of the wide-ranging horned lark. Streaked
20917 horned larks are small, ground-dwelling birds, approximately 6 to 8 inches in length. The
20918 combination of small size, dark brown back, and yellow on the underparts distinguishes this
20919 subspecies from other horned larks. The current range of the streaked horned lark can be
20920 divided into three regions: (1) the Puget lowlands in Washington, (2) the Washington coast and
20921 lower Columbia River islands (including dredge spoil deposition sites near the Columbia River in
20922 Portland, Oregon), and (3) the Willamette Valley in Oregon (USFWS 2018c).

20923 Streaked horned larks require wide-open spaces with no trees and few or no shrubs. They nest
20924 in the ground in sparsely vegetated sites. They use prairies, coastal dunes, sandy beaches, and
20925 grasslands. Occupied habitat adjacent to the Columbia River from Corbett, Oregon, west is
20926 designated critical habitat.

20927 **WESTERN YELLOW-BILLED CUCKOO**

20928 Western yellow-billed cuckoo was listed as threatened in November 2014. While critical habitat
20929 has been proposed by the USFWS, no portion of the CRSO study area was identified for
20930 designation. However, suitable habitat for yellow-billed cuckoo occurs throughout the
20931 Columbia River Basin where large remnant stands of forested wetland habitat occurs near
20932 Flathead Lake in Montana, the Clearwater in Idaho, and along the Columbia and Snake Rivers in
20933 Washington State. The yellow-billed cuckoo breeds throughout much of the eastern and central
20934 United States, winters almost entirely in South America east of the Andes, and migrates
20935 through Central America (USFWS 2018e).

20936 The western yellow-billed cuckoo uses wooded habitat with dense cover and water nearby,
20937 including woodlands with low, scrubby vegetation, overgrown orchards, abandoned farmland,
20938 and dense thickets along streams and marshes. In the western United States, cuckoo nests are
20939 often placed in willows along streams and rivers, with nearby cottonwoods serving as foraging
20940 sites (USFWS 2018e).

20941 **UTE LADIES'-TRESSES**

20942 Ute ladies'-tresses was listed as threatened in January 1992. Part of its range includes a small
20943 area adjacent to the Columbia River in Chelan, Okanogan, and Douglas Counties, north of
20944 Wenatchee, Washington. It is a rare perennial, terrestrial orchid with stems 8 to 20 inches tall.
20945 The orchid occurs along riparian edges, gravel bars, old oxbows, and high flow channels, and
20946 moist wet meadows along perennial streams (USFWS 2018g).

20947 Potentially suitable habitat occurs on stabilized gravel bars and/or shoreline areas along the
20948 Columbia River that are moist throughout the growing season and inundated early into the
20949 growing season. While the species has a wide range across the western United States, within
20950 the action area, the plan is currently documented in Washington State, occurring along the
20951 Rocky Reach Reservoir on gravel bars adjacent to the Columbia River in Chelan County,
20952 Washington (Fertig et al. 2005).

20953 Natural flooding cycles are important for creating new alluvial habitat and for reducing cover of
20954 competing plant species for Ute ladies'-tresses throughout their range, including along the
20955 Columbia River (Fertig et al. 2005). While discharge from Chief Joseph Dam influences
20956 downstream flows, the water surface elevation in Rocky Reach reservoir is primarily controlled
20957 by the operation of Rocky Reach Dam, which is owned and managed by Chelan County Public
20958 Utility District.

20959 **SOUTHERN RESIDENT KILLER WHALE DISTINCT POPULATION SEGMENT**

20960 The Southern Resident killer whale DPS is a single population totaling 78 individuals as of 2016
20961 (Centre for Whale Research 2016). The population ranges from central California to southeast
20962 Alaska. During the period from July to September, the DPS inhabits the Salish Sea and the
20963 waters near the entrance of the Strait of Juan de Fuca. Winter habitat frequently includes the
20964 Washington coast and less often the coastal waters of central California by two of the three
20965 pods (K and L) (NMFS 2014). There is no critical habitat designated within the CRSO study area;
20966 however, NMFS has proposed critical habitat for the Pacific Ocean marine water along the West
20967 Coast between Cape Flattery, Washington, and Point Sur, California, as for the Southern
20968 Resident killer whale DPS (84 FR 49214).

20969 The National Marine Fisheries Service (NMFS) has analyzed Chinook salmon stocks based on
20970 their estimated importance to the whales and found that the most crucial stocks are those
20971 returning to the Fraser River in British Columbia, other rivers draining into Puget Sound and the
20972 Salish Sea, and the Columbia, Snake, Klamath, and Sacramento Rivers. The NMFS analysis
20973 showed that Puget Sound Chinook salmon stocks are one of the most important salmon stocks
20974 for Southern Resident killer whale because the whales have access to them for a greater part of
20975 the year than fish from the Columbia, Snake, and Fraser Rivers. Other Chinook salmon stocks
20976 from the Columbia River Basin vary in overall importance for the diet of Southern Resident killer
20977 whale. For example, Snake River spring-summer Chinook salmon are mainly available to
20978 Southern Resident killer whale when the fish gather off the mouth of the Columbia River,
20979 whereas Snake River fall Chinook remain closer to the coast and would be available for a longer
20980 period before migrating upriver in the fall (NMFS 2014b, 2018; NMFS and WDFW 2018). At
20981 times or locations of low Chinook salmon abundance, whales also select other species such as
20982 chum salmon, smaller salmonids, or other non-salmonid prey (herring or rockfish).

20983 **STELLER SEA LION**

20984 The Eastern DPS of the Steller sea lion occurs along the West Coast between Washington and
20985 California. The Steller sea lion is the largest member of the family Otariidae, the “eared seals.”
20986 Steller sea lions are opportunistic predators, foraging and feeding near shore and in open
20987 waters on a wide variety of fishes and cephalopods (NMFS 2014a). The Steller sea lion was
20988 previously listed under the ESA and the Eastern DPS was delisted in 2014 because it had met its
20989 recovery goals (NMFS 2013). In 2010, the NMFS status assessment estimated the population
20990 included approximately 70,000 individuals and had maintained a positive growth rate for
20991 several years; the Western DPS (Steller sea lions born west of Cape Suckling, Alaska, at 144
20992 degrees west longitude) is still listed as endangered under the ESA (NMFS 2013). The Eastern
20993 DPS is still protected under the Marine Mammal Protection Act (MMPA) in all areas where
20994 individuals occur.

20995 In the Columbia River, Steller sea lion use the South Jetty on the Oregon shore at the mouth of
20996 the Columbia River as a haul out area, but no reproductive activity has been documented there;
20997 the Steller sea lion has not been observed using the North Jetty on the Washington shore as a
20998 haul out area. The closest breeding rookery to the Columbia River is on the southern Oregon

20999 coast at Rogue Reef. Use of the South Jetty by Steller sea lion occurs year round but is heaviest
21000 from April through October when as many as 200 to 300 individuals can be present. Steller sea
21001 lions typically forage at river mouths and coastal nearshore areas; however, some individuals
21002 are regularly observed foraging on white sturgeon and migrating adult salmon as far upstream
21003 as Bonneville Dam on the Columbia River and Willamette Falls on the Willamette River.
21004 Between 2002 and 2017, the number of Steller sea lions foraging at Bonneville dam has
21005 increased from 0 individuals in 2002 to a high of approximately 69 in 2015 (Tidwell et al. 2018).

21006 **CALIFORNIA SEA LION**

21007 Like Steller sea lion, the California sea lion is an eared seal native to the West Coast of North
21008 America where they live in coastal waters and on beaches, docks, buoys, and jetties. The
21009 California sea lion is distributed from the southern tip of Baja California to southeast Alaska,
21010 and they are protected under the MMPA in all areas. The California sea lion breeds in rookeries
21011 in southern California and Baja California and individuals move north after the breeding season
21012 to forage in productive nearshore areas along the Pacific coast. In 2007, the minimum
21013 population for California sea lion was estimated at approximately 150,000 individuals and the
21014 population has experienced a positive growth rate since the 1970s (NMFS 2015). The primary
21015 diet of California sea lion is a variety of fish and shellfish, including salmon, steelhead, Pacific
21016 whiting, herring, mackerel, eulachon, lamprey, codfish, walleye Pollock, spiny dogfish, and
21017 squid.

21018 In the Columbia River, California sea lion can be found on the South Jetty, piers, and docks in
21019 Astoria, Oregon. Since the mid-1980s, increasing numbers of California sea lion have been
21020 observed foraging on white sturgeon and migrating adult salmon at Bonneville Dam, 146 miles
21021 from the mouth of the river. Scat samples collected in coastal waters and in the Columbia River
21022 estuary indicate that salmon comprise 10 to 30 percent of the animals' diet (ODFW 2017).
21023 Between 2002 and 2017, the number of individual California sea lions observed foraging at
21024 Bonneville dam has increased from 30 animals in 2002 to a high of 195 in 2015 (Tidwell et al.
21025 2018). Foraging has also been observed at The Dalles Dam.

21026 **3.6.3 Environmental Consequences**

21027 **3.6.3.1 Methods and Assumptions**

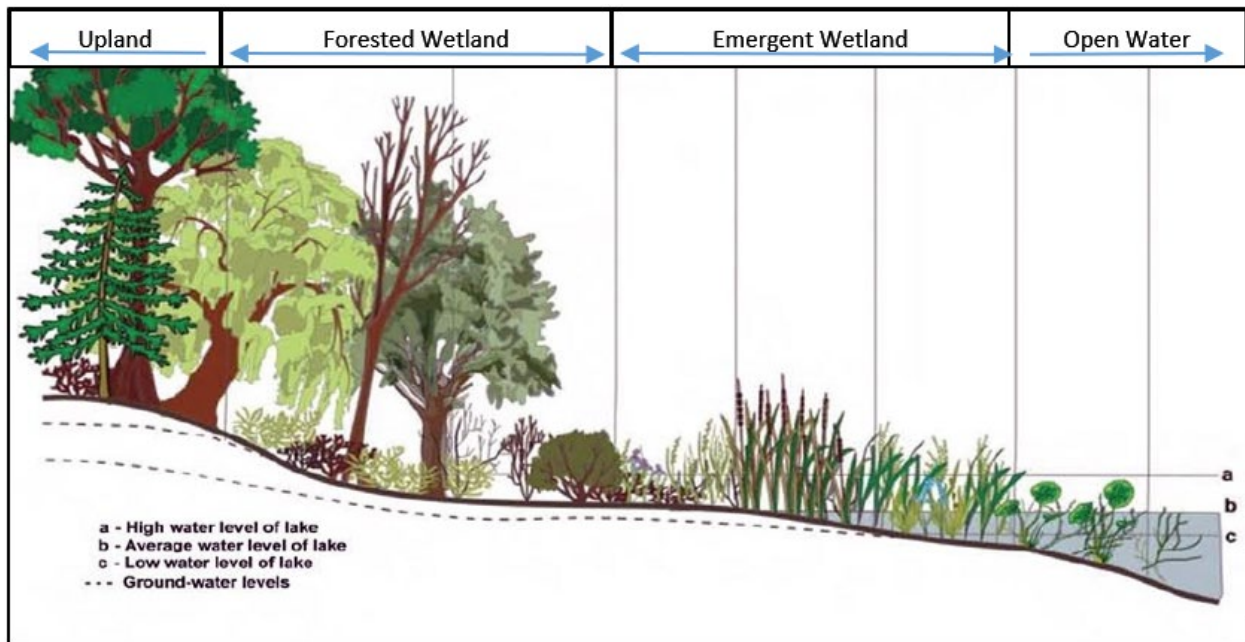
21028 **METHODS**

21029 Effects to vegetation, wetlands, and wildlife were quantitatively and qualitatively assessed
21030 using the best available science and technical methodologies that were accessible for the
21031 analysis area. H&H modeling, as described in Section 3.2, was used to estimate water surface
21032 elevations and identify the spatial patterns of inundation across the analysis area. The H&H
21033 output included seasonal water-level dynamics at discrete locations and inundated area
21034 polygons for peak annual water-surface profiles. Potential changes to water surface elevations
21035 and the timing and frequency of changes in the reservoir and downstream riverine portions of
21036 the Flathead, Kootenai, Pend Oreille, Snake, Clearwater, and Columbia Rivers were used to

21037 identify potential effects to habitat, vegetation, floodplains, and wildlife. For the action
21038 alternatives, results from the H&H modeling were evaluated on annual, seasonal, monthly, and
21039 where relevant, more frequent time-scales to assess change relative to the No Action
21040 Alternative and current conditions of the affected environment. H&H model index points were
21041 used to assess changes to water surface elevations and effects at potentially sensitive wildlife
21042 sites.

21043 Different habitat zones were identified in each reach using USFWS NWI maps, NWHI data, best
21044 professional judgment, referenced and local knowledge of the analysis area, and aerial
21045 photography. Where possible, the approximate elevations where one habitat type transitioned
21046 to another habitat type (for example, the elevation where forested and scrub-shrub wetlands
21047 transition to emergent herbaceous wetlands) were identified to assess potential effects. These
21048 approximate elevations were calculated using GIS methods in which the NWHI land cover and
21049 NWI data layers were overlaid on a 1-meter digital elevation model relief map.

21050 In general, the transition zones from emergent herbaceous wetlands to forested and scrub-
21051 shrub wetlands, and forested and scrub-shrub wetlands to upland habitats are dependent upon
21052 water surface elevations during the growing season (Figure 3-148). Changes to water surface
21053 elevations during the growing season have the potential to impact wildlife phenology and
21054 fecundity. A decrease in water surface elevation leads to drier conditions, habitat transition, or
21055 plant composition shifts to those more tolerant of dry or drought conditions. An increase in
21056 water surface elevation leads to wetter conditions, habitat transition, or plant composition
21057 shifts to those more tolerant of wet or inundation conditions.



21058
21059 **Figure 3-148. Diagram of Upland and Wetland Transition Zones Typical of Proximity to Water**
21060 **Surface Elevations**

21061 The effects of the alternatives on flood risks to property, structures, and human safety are
21062 evaluated in Section 3.9.4. The potential effects of the alternatives on the natural benefits
21063 provided by relatively undisturbed or restored floodplains are evaluated in this section. These
21064 benefits, described in Section 3.6.2.1, can be affected by changes in the frequency, timing,
21065 duration, and inundation area of flooding. The potential effects of the alternatives on the
21066 frequency and inundation area of flooding were evaluated by examining the change in flood
21067 elevation for a range of flood frequencies, from regularly occurring floods with an AEP of 50
21068 percent (i.e., the flood elevation that occurs once every 2 years, on average) to the base flood
21069 with an AEP of 1 percent (the flood elevation with a 1 percent chance of being exceeded in any
21070 given year). If an alternative is predicted to cause a minimal change in flood elevations over this
21071 range of flood frequencies (AEP from 50 to 1 percent) for a given reach, it is indicative of the
21072 probability of inundation remaining unchanged from current conditions for the floodplain
21073 adjoining the reach; therefore, the benefits provided by the floodplain would be unchanged
21074 from the No Action Alternative. Tables of flood elevation changes for AEP values from 50 to 1
21075 percent were provided by the H&H modeling team. Table 5-6 in Appendix B, *H&H*, shows
21076 results for the lower Columbia River below Bonneville Dam. Changes in flood elevations for
21077 floods occurring less frequently than the base flood (i.e., the critical action flood) were not
21078 evaluated due to uncertainties in the H&H simulation results for floods more rare than the base
21079 flood.

21080 In terms of describing severity of effects, the descriptors defined in Section 3.1 are used to
21081 describe the anticipated magnitude of effect (No Effect, Negligible Effect, Minor Effect,
21082 Moderate Effect, and Major Effect) based on effect level described in Chapter 2.

21083 In addition to the effects of changes in flood frequency and inundation area, the potential
21084 effects from changes in the timing and duration of flooding on vegetation, wetlands, and
21085 wildlife are discussed below. The potential effects on fish from changes in the timing and
21086 duration of flooding are discussed in Section 3.5.2.

21087 **ASSUMPTIONS**

21088 For all alternatives, except MO3, the analysis assumes that all ongoing, scheduled, and routine
21089 maintenance activities for the Federal infrastructure and all structural features, including those
21090 recently constructed or reasonably foreseeable to be constructed, are included and would be
21091 implemented as planned prior to September 30, 2016. For MO3, dam breaching would preclude
21092 the need for maintenance at the lower Snake River dams.

21093 For structural changes at dams under MO1, MO2, and MO4, the construction and modification
21094 of existing structures would have relatively minor effects on existing habitats and wildlife
21095 populations. Typical construction-related effects would include, but are not limited to,
21096 temporary and short-term increases in noise, clearing or grading vegetation, erosion control,
21097 fish salvage and removal prior to commencing in-water work, and work-area isolation. These
21098 actions could result in a temporary displacement of wildlife from preferred or suitable habitat
21099 or changes in behavior if animals are near a project during construction. Where new structures
21100 are constructed, it is assumed that efforts would be made to avoid effects to wildlife habitat,

21101 and where habitat effects could not be avoided, efforts would be made to minimize and
21102 possibly mitigate potential effects to habitat and wildlife populations by implementing best
21103 management practices (BMPs) to minimize potentially deleterious effects. It is further assumed
21104 that construction activities would be detailed and designed at a future date and individual
21105 construction actions would undergo additional analysis, if needed when the effects are
21106 different from or exceed those anticipated herein. For structural changes under MO3 (e.g., dam
21107 breaching), it is assumed there would be major effects on existing habitats and wildlife
21108 populations.

21109 BMPs for construction-related activities typically include taking measures to minimize dust,
21110 conducting plant and wildlife surveys prior to construction, working outside of the migratory
21111 bird nesting times, minimizing ground disturbance or limiting it to areas already disturbed,
21112 managing for surface water runoff, and having appropriate containment for fuels and other
21113 materials, etc.

21114 Several programs are in place in the lower Columbia River to manage or dissuade pinniped and
21115 avian predation on salmonids. All alternatives assume that existing and ongoing predator
21116 control programs and other project operations would continue. These plans include the Inland
21117 Avian Management Plan (Corps 2018), The Caspian Tern Management to Reduce Predation of
21118 Juvenile Salmonids in the Columbia River Estuary (USFWS 2005), and the Double-crested
21119 Cormorant Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Inlet (Corps
21120 2015).

21121 Throughout the study area, USFWS, ODFW, Montana Fish, Wildlife, and Parks (MFWP), and
21122 Washington Department of Fish and Wildlife (WDFW), and other tribal and governmental
21123 entities manage wetland habitats and other wildlife habitat areas to support fish and wildlife.
21124 Through its Fish and Wildlife (F&W) Program, Bonneville has implemented wildlife habitat
21125 projects to address the impact of the development of the CRS, many of which were
21126 permanently acquired for wildlife habitat and provide important benefits for fish. Bonneville
21127 also provides operations and maintenance funding for these projects. The alternatives assume
21128 that the wildlife area managers would continue to implement management activities consistent
21129 with management area and refuge goals and agency policies for the benefit of fish and wildlife.

21130 In the lower Columbia River, below Bonneville Dam, much of the historical floodplain has been
21131 levied to protect communities from flooding. Vegetation on levees is managed for structural
21132 integrity, limiting potential habitat development immediately adjacent to the river. Routine
21133 operations and levee maintenance actions would continue under all alternatives in patterns
21134 similar to current practices. In areas where levees are not regularly maintained, some erosion or
21135 degradation is evident and these areas would continue degrading consistent with current trends.

21136 Both the Corps and Reclamation engage in cooperative weed management agreements to treat
21137 weeds and prevent infestations of invasive species, including aquatic invasive species,
21138 throughout the study area. For example, the Corps currently manages flowering rush (*Butomus*
21139 *umbellatus*) and other aquatic invasive species in the McNary Reservoir on submerged Federal
21140 lands through the aquatic portion of the Walla Walla District Integrated Pest Management

21141 Program (Corps 2019, NMFS 2019, USFWS 2019). Bonneville also provides funding to decrease
21142 the spread of non-native species through its F&W Program, such as weed control actions of
21143 wildlife mitigation properties and the removal of non-native fish species that depredate on
21144 native fish. Other similar management efforts, where applied, are anticipated to reduce the
21145 spread and establishment of invasive species throughout the study area. Invasive species
21146 management is expected to continue under all alternatives. Where no management efforts are
21147 implemented, invasive plant species are expected to persist and may spread to new areas. In
21148 terms of non-native wildlife species in the analysis area, none of the alternatives propose
21149 changes in operations that would lead to changes in populations or provide advantages to non-
21150 native wildlife over native wildlife. Therefore, they are not discussed further. Efforts currently in
21151 place to detect quagga (*Dreissena rostriformis bugensis*) and zebra mussels (*D. polymorpha*) to
21152 prevent their spread into the study area would continue and there are no measures that would
21153 impact their implementation.

21154 Throughout the study area, cottonwood (*Populus trichocarpa*) galleries (areas with highly fertile
21155 soils and water availability) and recruitment are an important habitat feature for wildlife and
21156 floodplain development. Cottonwood is a pioneer species adapted to colonize areas disturbed
21157 by floodwaters. Cottonwood seed dispersal occurs during high flows as seeds are deposited in
21158 the floodplain or above bankfull. Altered flows that do not access floodplains affect the
21159 recruitment and survival of saplings and can lead to cottonwood galleries consisting of old,
21160 mature trees that eventually die off with no new recruitment. Changes in water elevations and
21161 flows influence successful cottonwood germination and establishment. Increasingly dry
21162 conditions result in poor germination and reduced survival of cottonwood saplings if soil
21163 conditions do not retain sufficient moisture for seed germination in the spring. Subsequent high
21164 flows later in the summer or after seed dispersal and before saplings can establish strong root
21165 masses can uproot saplings. Winter conditions also influence survival of saplings and the
21166 regeneration of cottonwood forests. Ice formation in shallow-water areas, or along reservoir
21167 shorelines, can destroy sapling recruitment when water surface levels fluctuate. As water levels
21168 decrease, ice moves with the water. As pool elevations increase, ice moving along the shoreline
21169 or in shallow-water areas can scour the banks and pull entire generations of saplings out from
21170 the shoreline. This can effectively reduce the long-term regeneration of cottonwood galleries
21171 when aging forests are lost through natural succession. These relationships between operations
21172 and cottonwoods occur to some extent throughout the study area and are analyzed below
21173 where effects are particularly important.

21174 When the CRS dams were built and the reservoirs behind them filled, they inundated about
21175 308,996 acres, much of it important fish and wildlife habitat. To calculate the area affected by
21176 CRS development in each Region—dam construction and inundation by the reservoirs behind
21177 them—Bonneville relied on either the amounts agreed upon in negotiated mitigation
21178 agreements with state and tribal entities or the loss assessments prepared by Federal, state,
21179 and tribal wildlife managers. To date, Bonneville has implemented wildlife habitat projects on
21180 over 689,000 acres to address the impact of the development of the FCRPS, which includes the
21181 CRS, many of which were permanently acquired for wildlife habitat. Bonneville also provides
21182 operations and maintenance funding for these projects. The loss assessments relating to dam

21183 construction and inundation considered all habitat losses up to and including full reservoir pool
21184 levels. As such, mitigation for those losses can also serve to address the effects of reservoir
21185 operations on wildlife habitat, to the extent that such operational impacts occur below full pool
21186 level. These habitats would not change from current conditions in response to continued
21187 implementation of the No Action Alternative.¹

21188 **3.6.3.2 No Action Alternative**

21189 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

21190 Vegetation communities adjacent to the study area in Region A are dominated by upland
21191 habitat types consisting of agricultural and pasture lands, eastside (interior) grasslands, eastside
21192 (interior) mixed conifer forest, and eastside (interior) grasslands. The next most abundant
21193 habitat type, besides open water, is freshwater forested and scrub-shrub wetlands and
21194 freshwater emergent herbaceous wetlands. Wetlands are located below Libby Dam along the
21195 Kootenai River at river mile (RM) 131 through 136, 143 through 144, 184 through 190, and 216
21196 through 219. There are extensive wetlands from Hungry Horse Dam downstream to Flathead
21197 Lake, between approximately RM 111 and 140 along the Flathead River. Wetlands within the
21198 Albeni Falls Dam study area are located on the Clark Fork River at RM 4 through 8 and 73
21199 through 86.

21200 Throughout Region A, the acreages for the various habitat types would remain relatively
21201 unchanged from current conditions (except as described below for riparian and cottonwood
21202 habitats below Libby). Wetland habitats would not change under the No Action Alternative
21203 because the water surface elevations that influence these habitats would be consistent with
21204 current conditions. Operations that benefit wetland habitats by maintaining certain elevations
21205 around the reservoirs and downstream would not change under the No Action Alternative.
21206 Areas throughout Region A that are recovering from historical operations would continue to
21207 recover and areas that are degrading from ongoing operations would continue to degrade if
21208 additional mitigation is not implemented.

21209 Factors potentially altering streambank conditions, such as high flows, bankfull flows in the
21210 spring, or low-water conditions, would continue under the No Action Alternative. Existing
21211 streambank conditions, such as erosion and bank sloughing, influenced by water releases from
21212 the Federal projects would continue to occur along the Kootenai River from operations at Libby
21213 Dam. Shoreline erosion in Bonner's Ferry, Idaho, caused by frozen banks suddenly drawn down
21214 due to reduced flows, would continue to reduce wildlife habitat. The exception is the muddy
21215 eastern and northern shoreline of Lake Pend Oreille, where soils are highly erodible and
21216 fluctuating water levels from reservoir operations, boat wakes, and wind are expected to
21217 maintain erosional processes, contributing to increased undercutting of banks and shoreline

¹ Bonneville funded but did not control the production of wildlife habitat loss assessments by wildlife managers in the mid-1980s and early 1990s. These documents, also called "Brown Books," are on file with Bonneville. The Brown Books generally reflect the acres inundated by the FCRPS as determined by the surface area of the reservoirs created behind each dam. See, e.g., U.S. Fish and Wildlife Service, Wildlife Impact Assessment Bonneville, McNary, The Dalles, and John Day projects (Oct. 1990).

21218 collapse. It is expected that management activities would be implemented to address localized
21219 areas of erosion where they pose a risk to public safety.

21220 Operations at all three facilities expose a wide barren zone around the reservoirs during refill
21221 and drawdown. For wildlife, the barren zone represents an area that smaller wildlife species,
21222 such as rodents or snakes, must navigate to reach water in the reservoir. Crossing wide barren
21223 zones with no cover poses a risk of predation for prey species, which is a detriment to them,
21224 while conversely providing a benefit to predators (Huokuna et al. 2017). The barren zone width
21225 at each facility varies, but the effects on wildlife are similar in terms of predation and would
21226 continue unchanged under the No Action Alternative.

21227 In Region A, Bonneville addressed construction and inundation mitigation for Libby and Hungry
21228 Horse Dam wildlife using a comprehensive long-term agreement. Under the 1989 Montana
21229 Wildlife Mitigation Trust Agreement (Montana Fish, Wildlife, and Parks 2013), Montana has
21230 protected or enhanced 272,104 acres (Montana Fish, Wildlife, and Parks 2019) (the Council's
21231 program called for a total of 55,837 acres of wildlife mitigation for Libby and Hungry Horse
21232 Dams split between 29,171 acres of enhancement and 26,666 acres of protection; NPCC 1987;
21233 Montana Fish, Wildlife, and Parks 2009). In the 2018 Albeni Falls Dam Wildlife Mitigation
21234 Agreement, Bonneville and the State of Idaho established that 14,087 acres had already been
21235 mitigated through the efforts of the state, the Kalispel Tribe of Indians, Kootenai Tribe of Idaho,
21236 and Coeur d'Alene Tribe (6,617 acres were impacted as a result of the construction and
21237 inundation of Albeni Falls Dam; Northern Idaho MOA 2018). In addition, Bonneville agreed to
21238 fund the State of Idaho to protect and enhance 1,279 acres of wetland habitat at the Clark Fork
21239 Delta and an additional 99 acres at the Priest River Delta to address the upriver effects of Albeni
21240 Falls operations. This is in addition to the 624 acres of wetland protected and enhanced on the
21241 Clark Fork Delta by IDFG, which was funded by Bonneville through a letter agreement in 2012.

21242 From May 15 through September 30, operations at Libby Dam maintain higher flows (at or
21243 above 6 kcfs) to inundate the channel during the most biologically productive time of the year
21244 and exhibit a gradual decline over the summer. While operations at this location are primarily
21245 fish focused, wildlife habitats and wildlife populations would continue to benefit from increased
21246 water surface in the reservoir and water availability downstream, particularly during the
21247 summer months when temperatures are high and water levels inundate wetland habitats. The
21248 small wetland fringe in areas where the reservoir converges with small tributaries would
21249 continue to be inundated and benefit from operations.

21250 At Libby Dam and downstream along the Kootenai River, because high winter releases scour
21251 seedlings, some riparian cottonwood communities could continue to decline in some locations
21252 due to altered hydrological conditions.

21253 Through the F&W Program, Bonneville has funded the Kootenai Tribe of Idaho (KTOI) to
21254 manage and implement large-scale habitat restoration measures within the Kootenai River.
21255 These habitat restoration actions have increased active floodplain and worked to restore
21256 riparian forest habitat, including efforts to restore black cottonwood galleries. The efforts to
21257 restore black cottonwood galleries within floodplains and along river corridors are being

21258 implemented within the upper basin by the Kootenai Tribe of Idaho, (KTOI) the Kalispel Tribe,
21259 and the Idaho Department of Fish & Game (IDFG) through Bonneville's F&W Program. The KTOI
21260 have been implementing re-planting efforts below Libby Dam within the Idaho portion of the
21261 Kootenai River. The Kalispel Tribe has been planting black cottonwoods in Washington and
21262 Idaho above and below Albeni Falls Dam, both within floodplain areas and along the Pend
21263 Oreille River. IDFG, in their work to restore portions of the Clark Fork Delta, have been
21264 conducting revegetation efforts with native black cottonwoods. Mitigation actions like these
21265 would continue under the No Action Alternative.

21266 Under the No Action Alternative, cottonwood seed deposition occurs after high flows in June
21267 and July moisten the riverbanks, and seeds are dispersed from parent trees in late summer.
21268 Winter flows can inundate and scour riverbanks, destroying tree and shrub saplings like
21269 cottonwoods and willows (*Salix* spp.) that have not yet developed sufficient root structures to
21270 withstand high winter flows or the spring freshet.

21271 The Kootenai Wildlife Refuge contains 2,774 acres of wetlands, meadows, riparian forests, and
21272 cultivated agricultural fields, which provide habitat for over 220 bird species and 45 mammal
21273 species. The seasonal wetlands are drained in spring and summer to promote emergent
21274 vegetation for waterfowl food sources. Current operations of Libby Dam adversely affect
21275 wetland management capability, reducing availability of forested and scrub-shrub and
21276 emergent herbaceous wetlands (USFWS 2015).

21277 The size and depth of Lake Pend Oreille (approximately 94,600 acres and maximum depth of
21278 1,237 feet) would remain unchanged under the No Action Alternative and the estimated
21279 ordinary high water elevation in the summer and fall (2,062.5 feet and 2,051 feet NGVD29,
21280 respectively) would remain unchanged throughout the year.

21281 Consistent with current management practices, the Corps would continue to lease
21282 approximately 4,000 acres of project lands in the Albeni Falls Dam study area to the State of
21283 Idaho for wildlife management. The Pend Oreille Wildlife Management Area (WMA) would be
21284 inundated for 4 to 5 months each year, with less than 25 percent of the area above the high-
21285 water line. Habitat in the WMAs range from mudflats exposed during reservoir drawdown in
21286 the winter to submerged lands with rooted aquatic plants and forested uplands. During the
21287 summer months under the No Action Alternative, most of the Pend Oreille WMA is emergent
21288 marsh habitat and with an average water depth of 2 to 4 feet surrounded by a narrow zone of
21289 sedges, cottonwoods, and willows. Conifers occur further inland.

21290 Amphibians such as the western toad (*Bufo boreas*) and northern leopard frog (*Rana pipiens*)
21291 would continue to breed in off-channel pools and forested woodlands along slow-moving rivers
21292 in Montana and Idaho from early May until late June. Tadpoles are generally present from late
21293 May to early September.

21294 Western grebe (*Aechmophorus occidentalis*) is abundant on portions of the Pend Oreille WMA,
21295 particularly in Denton Slough where one of only a few northern Idaho nesting colonies occurs.
21296 Nesting occurs from about May through September. Denton Slough is a shallow bay with a

21297 large quantity of submerged plants. These plants are used by western grebe to construct their
21298 nests, which are composed of piles of floating plant material that are typically hidden among,
21299 and may be anchored to, emergent or floating plants (Idaho Department of Fish and Game
21300 [IDFG] 1999).

21301 The Canada goose (*Branta canadensis*) ground nests near the Priest Lake portion of the WMA
21302 along the shore and on islands (IDFG 1999). Other common nesters include mallard (*Anas*
21303 *platyrhynchos*); American widgeon (*Mareca americana*); gadwall (*M. strepera*); northern
21304 shoveler (*Spatula clypeata*); ring-necked duck (*Aythya collaris*); and green-winged, blue-winged,
21305 and cinnamon teal (*Anas crecca*, *Spatula discors*, and *S. cyanoptera*, respectively) (IDFG 1999).

21306 In regard to potential effects in Canada, the effects on vegetation and wildlife resources and
21307 their habitats under the No Action Alternative are expected to be similar to the effects
21308 described for the United States portion of Region A.

21309 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

21310 Vegetation communities in Region B are primarily dominated by upland habitats. Upland
21311 habitats near the Chief Joseph Dam trend toward agricultural and pasture lands, with some
21312 shrub-steppe habitat, while upland habitats near the Grand Coulee Dam are primarily
21313 dominated by agricultural and pasture land, ponderosa pine (*Pinus ponderosa*) forests and
21314 woodlands, and shrub-steppe habitat. The next most common habitat type in Region B, besides
21315 open water, is forested and scrub-shrub wetlands. Emergent herbaceous wetlands, while
21316 sparse throughout the region, occur in isolated pockets along the rivers and lake shorelines.
21317 Uplands occur above the forested and scrub-shrub wetland habitat in both zones. There are
21318 approximately 1,600 acres of urban and mixed-use environment throughout Reach B.

21319 Operations at Grand Coulee expose a wide barren zone around the Lake Roosevelt during refill
21320 and drawdown. For wildlife, the barren zone represents an area that smaller wildlife species,
21321 such as rodents or snakes, must navigate to reach water in the reservoir. Crossing wide barren
21322 zones with no cover poses a risk of predation for prey species, which is a detriment to them,
21323 while conversely providing a benefit to predators. The effects on wildlife are similar in terms of
21324 predation and would continue unchanged under the No Action Alternative.

21325 Approximately 1,426 acres of forested and scrub-shrub wetlands are located within Region B.
21326 These wetlands are composed mainly of cottonwoods and willows.

21327 Habitat types in Region B would not shift or transition to other habitat types, and the spatial
21328 extent of existing habitats would not increase or decrease as a function of the No Action
21329 Alternative. Water surface elevations, which influence wetland habitats throughout the study
21330 area, would continue consistent with current operations and patterns of inundation would
21331 continue to support these habitats following expected patterns of seasonal and annual
21332 fluctuation. Island habitats and barren areas surrounding the reservoirs would also continue to
21333 be present in amounts similar to current conditions. Wildlife use of these habitats would not

21334 change in response to implementing operational or structural measures associated with the No
21335 Action Alternative.

21336 In this region, project partners like WDFW, Spokane Tribe of Indians (STOI), and Confederated
21337 Tribes of the Colville Reservation (CTCR) manage wildlife mitigation properties funded through
21338 the Bonneville F&W Program for wildlife mitigation. Under a 2008 agreement between
21339 Bonneville and CTCR, CTCR acquired almost 4,000 acres, which are part of the Hellsgate Game
21340 Reserve. In addition, CTCR has completed extensive habitat restoration and maintenance
21341 actions, such as invasive species and noxious weed control measures and fencing modifications
21342 to benefit reintroduced pronghorn antelope. Similar mitigation actions would continue to be
21343 implemented in Region B under the No Action Alternative.

21344 Streambank conditions, such as erosion and bank sloughing, and vegetation along the Columbia
21345 River are influenced by water releases from Chief Joseph Dam and Grand Coulee Dam. Under
21346 the No Action Alternative, conditions affecting shorelines are expected to continue and factors
21347 influencing these, such as high flows, or bankfull flows in the spring, would continue consistent
21348 with current conditions. Furthermore, areas recovering from historical operations are expected
21349 to continue to recover, and areas that generally transition from open water directly to upland,
21350 due to the non-existence of established wetland habitats, will remain the same.

21351 The overall wildlife values at Lake Roosevelt are limited because of the lake's storage function
21352 and substantial seasonal drawdowns, which adversely affect shorelines and the development of
21353 wildlife habitat. Habitats important to wildlife in Region B are generally confined to tributary
21354 stream reaches, embayments and backwaters, and islands; conditions are much less favorable
21355 on the main reservoir where steep, eroding banks are prevalent. Islands are important in part
21356 because only 28 remain of the 114 identified in a pre-construction assessment of the Columbia
21357 River in Region B. In general, riparian and wetland habitats exist only as small, isolated habitats
21358 around Rufus Woods Lake and Lake Roosevelt.

21359 Winter conditions that influence predator-prey relationships in areas such as Lake Roosevelt,
21360 Lake Kootenai, and Flathead Lake would continue. Shallow-water coves and embayments
21361 frequently freeze completely in the winter.

21362 Both mountain lion (*Puma concolor*) and wolf (*Canis lupus*) are known to hunt or pursue prey
21363 species such as bighorn sheep (*Ovis canadensis*) and deer (*Odocoileus hemionus*) into barren
21364 zones or onto the ice in the winter. The mountain lion is more successful in its capture and kill
21365 rates when the water levels are lower in the winter or the reservoir does not refill completely
21366 before lake conditions freeze. Under these conditions, mountain lion pursue ungulates such as
21367 the bighorn sheep into the barren zone where the surface is predominantly soil instead of rock.
21368 When ungulates (i.e., elk, bighorn sheep, deer) are pushed into areas with soft sediments, they
21369 have difficulty escaping. The wolf, however, is more successful in its capture and kill rate when
21370 the water levels are higher during the winter and areas of the reservoir freeze over. Under
21371 these conditions, the wolf hunts and pursues deer and elk (*Cervus canadensis*) onto the ice
21372 where the wolf has better traction over snow and ice. Amphibians such as the western toad
21373 (*Bufo boreas*) and northern leopard frog (*Rana pipiens*) would continue to breed in off-channel

21374 pools and along the fringes of Lake Roosevelt and slow-moving sections of the Columbia River
21375 from early May until late June. Tadpoles are generally present from late May to early
21376 September.

21377 In regard to potential effects in Canada, the effects on vegetation and wildlife resources and
21378 their habitats under the No Action Alternative are expected to be similar to the effects
21379 described for the United States portion of Region B.

21380 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
21381 **HARBOR DAMS**

21382 Vegetation communities adjacent to and downstream of the Dworshak Dam are dominated by
21383 upland habitat types, including eastside interior shrublands, eastside interior mixed conifer
21384 forest, ponderosa pine and eastside white oak forest woodlands. At Dworshak, emergent
21385 herbaceous wetlands are present generally at the highest water elevation, approximately 1,600
21386 feet, at the confluences of tributaries. Downstream of Dworshak on the Clearwater River,
21387 emergent herbaceous and forested and scrub-shrub wetlands occur within 5 feet of water
21388 surface elevation.

21389 Dworshak's 80-foot barren zone is caused by the fluctuations of the reservoir between
21390 maximum and minimum operating pool. Since the late 1990s, the reservoir has been drawn
21391 down to 80 feet annually between July and October to improve passage and survival of
21392 endangered salmon in the Clearwater and Snake Rivers. Dworshak Reservoir does not fill until
21393 the end of June. During most of the year, large mud flats, sandy banks, and rocky slopes are
21394 visible. This has affected the elk populations during the winter months when ice freezes along
21395 the reservoir. When ice is present, elk may cross the reservoir to reach their south-facing winter
21396 range on the northern end of the reservoir. Migration across the ice occurs frequently when ice
21397 and snow conditions permit. In winters when snow accumulates on thin ice, elk and deer may
21398 fall through the ice and mortality may occur. Although mortality rates are highly variable, in
21399 some years, this can be a major source of mortality.

21400 Wetlands along the Clearwater River are located in areas where sediment accretes at the
21401 confluence of the river with its tributaries. Hog Island, located at approximately RM 9, is a large
21402 island that includes emergent herbaceous wetlands.

21403 The four lower Snake River projects are primarily dominated by the upland habitat types of
21404 agricultural and pasture lands and shrub steppe habitat. There are forested and scrub-shrub
21405 wetlands at Lower Granite Reservoir (Reach 9); however, most of the wetlands found at the
21406 lower Snake River projects are emergent herbaceous wetlands. There are large wetland areas
21407 located at Silcott Island (RM 131), within Lower Granite Reservoir at RM 80, and in Little Goose
21408 Reservoir at RM 58 and Lower Monumental Reservoir at RM 17. Wetlands occur approximately
21409 3 feet from maximum operating pool elevation within the lower Snake River projects.

21410 Habitat types in Region C would not shift or transition to other habitat types, and the spatial
21411 extent of existing habitats would not increase or decrease as a function of the No Action

21412 Alternative. Water surface elevations, which influence wetland habitats throughout the study
21413 area, would continue consistent with current operations and patterns of inundation would
21414 continue to support these habitats following expected patterns of seasonal and annual
21415 fluctuation. Island habitats and barren areas surrounding the reservoirs would also continue to
21416 be present in similar amounts to current conditions. Wildlife use of these habitats would not
21417 change in response to implementing operational or structural measures associated with the No
21418 Action Alternative.

21419 Streambank conditions, such as erosion and bank sloughing, and vegetation along the
21420 Clearwater, Snake, and Columbia Rivers in Region C, are influenced by water releases from
21421 Dworshak Dam, Hells Canyon Complex, and the four projects on the lower Snake (Ice Harbor,
21422 Lower Monumental, Little Goose, and Lower Granite). Under the No Action Alternative,
21423 shoreline conditions would continue and factors influencing these, such as high flows, or
21424 bankfull flows in the spring, would continue under the No Action Alternative consistent with
21425 current conditions. Furthermore, areas recovering from historical operations would continue to
21426 recover.

21427 The Dworshak Dam lands would continue to be managed for elk populations, wildlife habitat,
21428 and recreational use.

21429 The 1992 Dworshak wildlife mitigation agreement with the State of Idaho, Nez Perce Tribe, and
21430 Bonneville, frequently referred to as the “Dworshak Settlement,” mitigated the impacts to
21431 wildlife from developing that dam estimated at 16,970 acres. To determine acreage protected,
21432 Bonneville relied on the Dworshak Wildlife Agreement reports from the Nez Perce Tribe. The
21433 Tribe’s 2018 annual report indicates it has purchased 7,576 acres and still has over \$9.5 million
21434 remaining in its mitigation fund established under the agreement (Nez Perce Tribe 2018). The
21435 State of Idaho also has a \$3 million fund provided by Bonneville to manage the 60,000-acre
21436 Peter T. Johnson Unit of the Craig Mountain Wildlife Management Area (formerly known as
21437 Craig Mountain), which Bonneville purchased and transferred to Idaho (IDFG 2014). All told,
21438 Bonneville has funded approximately 67,576 acres of mitigation for Dworshak Dam. Many of
21439 these mitigation sites are located outside of the study area.

21440 Most of the approximate 147 miles of shoreline along the lower Snake River are managed by
21441 the Corps as mitigation areas as part of the Lower Snake River Compensatory Mitigation Plan
21442 (Corps 1975, 1996). These areas are managed to provide wildlife habitat and recreation areas.
21443 Under the No Action Alternative, the wildlife would continue to utilize the habitat types. These
21444 species include mule deer, fox, raccoons, bobcat, turkey, and various songbirds as well as otter,
21445 beaver, muskrat, and various ducks.

21446 In addition to these areas, Bonneville secured another 61,210 acres of wildlife mitigation
21447 through habitat protection and enhancement projects implemented by the Nez Perce Tribe and
21448 Burns Paiute Tribe. For example, the Nez Perce Tribe received funding through Bonneville’s
21449 F&W Program to acquire the 16,286-acre Precious Lands project near Joseph, Oregon, outside
21450 the study area.

21451 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

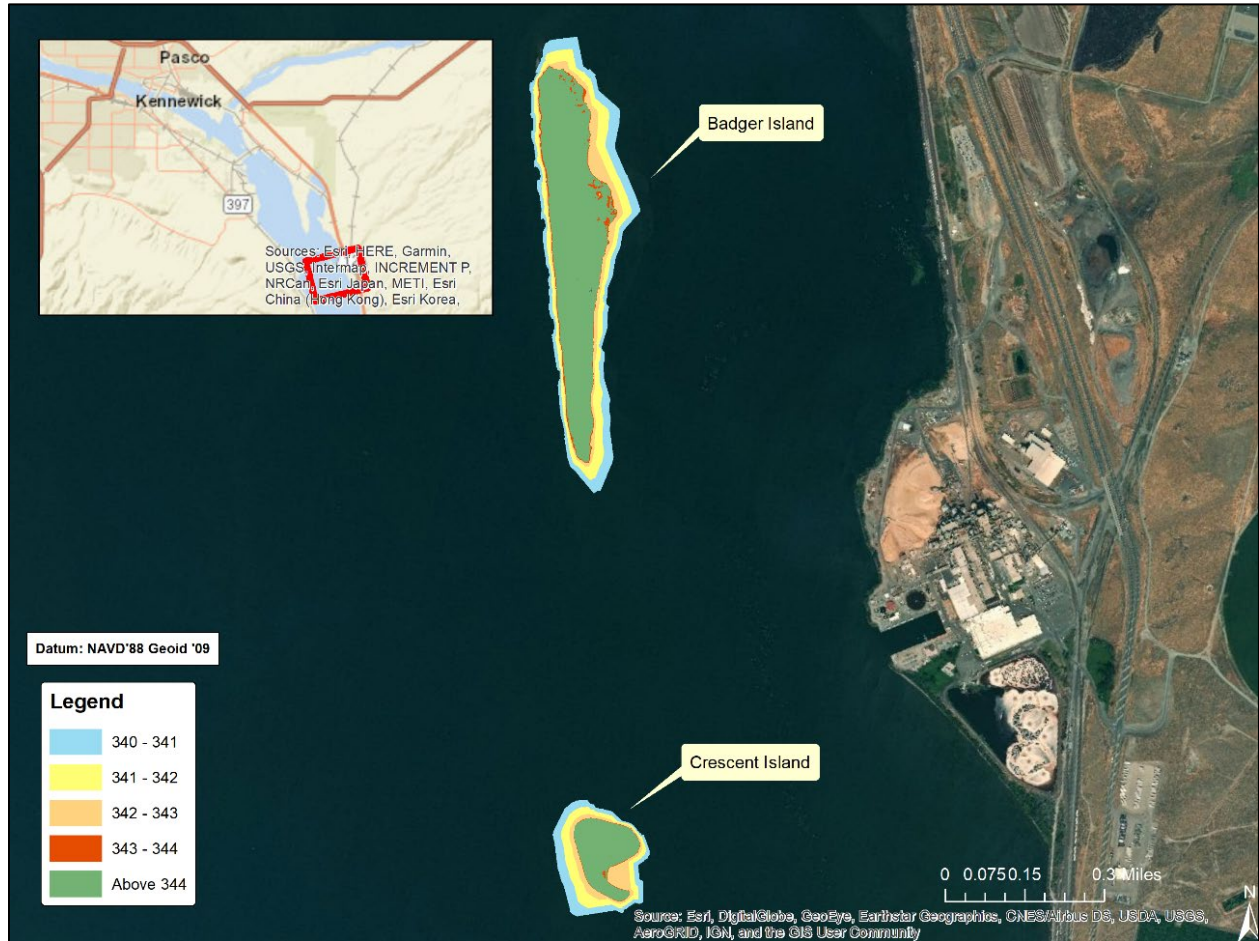
21452 Habitats in Reach D transition from dry, Columbia River Plateau habitat types to wet forests of
21453 the Cascade Range and Oregon Coast Range. Upland habitat adjacent to John Day Dam and The
21454 Dalles study areas largely consists of shrub-steppe vegetation, mixed grasslands, and
21455 agricultural areas farmed for dryland wheat, alfalfa, barley, and vineyards. The distribution and
21456 spatial extent (overall acreage) of uplands managed by the Corps would not change under the
21457 No Action Alternative. Where upland habitats transition abruptly to the river's edge and no
21458 riparian habitat exists, there are few areas where habitat is exposed for prolonged periods of
21459 time and shoreline habitat is predominantly bedrock, sand, gravel, and silts with limited or no
21460 vegetation. Within the McNary Reservoir, there are extensive wetlands within the McNary
21461 Wildlife Area at Burbank Slough (RM 319 to 324) and mudflats at the confluence of the Walla
21462 Walla River (RM 313 to 315). The Yakima Delta contains some cottonwood forest habitat (RM
21463 333 to 335).

21464 Within the McNary Reservoir, Crescent Island (RM 316) was managed (fence and willow
21465 plantings) to discourage tern nesting, and monitoring of the Island would continue under the
21466 No Action Alternative (Corps 2018). The acreage of available habitat for avian predators is
21467 dependent on water surface elevation. Under the No Action Alternative, there is approximately
21468 0.25 acre of suitable nesting habitat on Badger Island, depending on river flows, and the island
21469 supported 60 breeding pairs of Caspian terns in 2012 (Bird Research Northwest 2013). Wildlife
21470 use of these habitats would not change due to operational or structural measures associated
21471 with the No Action Alternative. On Crescent Island, approximately 2.4 acres of potential Caspian
21472 tern nesting habitat has been covered with passive nest dissuasion materials consisting of
21473 fencerows. Open areas on Crescent Island were planted with willow and other native
21474 vegetation prior to the 2016 nesting season.

21475 Water surface elevations under current operations, which influence the distribution and
21476 maintenance of wetland habitats, would continue and current trends for habitat quality,
21477 quantity, and distribution would not deviate from current conditions. The distribution and
21478 acreage of wetland habitat in the upper portion of Region D (The Dalles and John Day study
21479 areas) is limited due to the close relationship of highways and railroads to the river's shorelines.
21480 Forested and scrub-shrub and emergent herbaceous wetlands occur in embayments formed by
21481 the location of highways and railroads adjacent to the river at elevations of 14 to 26 feet, above
21482 which habitats transition abruptly to upland land cover types. In the lower portion of Region D
21483 (downstream of The Dalles Dam), the distribution and acreage of wetland habitats increases,
21484 becoming extensive throughout the lower Columbia River, where emergent herbaceous
21485 wetlands occur at elevations of 1 to 10 feet. Wildlife use of habitats would not change in
21486 response to operations or structural measures associated with the No Action Alternative.

21487 There is very little erosion or bank sloughing in the upper portions of Region D (The Dalles and
21488 John Day study areas) due to shorelines consisting almost entirely of bedrock. Under the No
21489 Action Alternative, these patterns would not change and factors influencing shoreline
21490 conditions, such as high-flow years or low-flow years, would continue. Under the No Action

21491 Alternative, patterns of accretion and erosion in the lower portions of Region D would not
21492 change substantively from current conditions, and factors influencing shoreline conditions and
21493 erosional patterns, such as high-flow years or low-flow years, would continue similar to current
21494 conditions. As a result, due to increasing erosion in the lower portions of Region D, the spatial
21495 extent and acreage of sandy shorelines is expected to decline, reducing habitat available for
21496 species using these habitats.



21497
21498 **Figure 3-149. Crescent Island in McNary Reservoir**

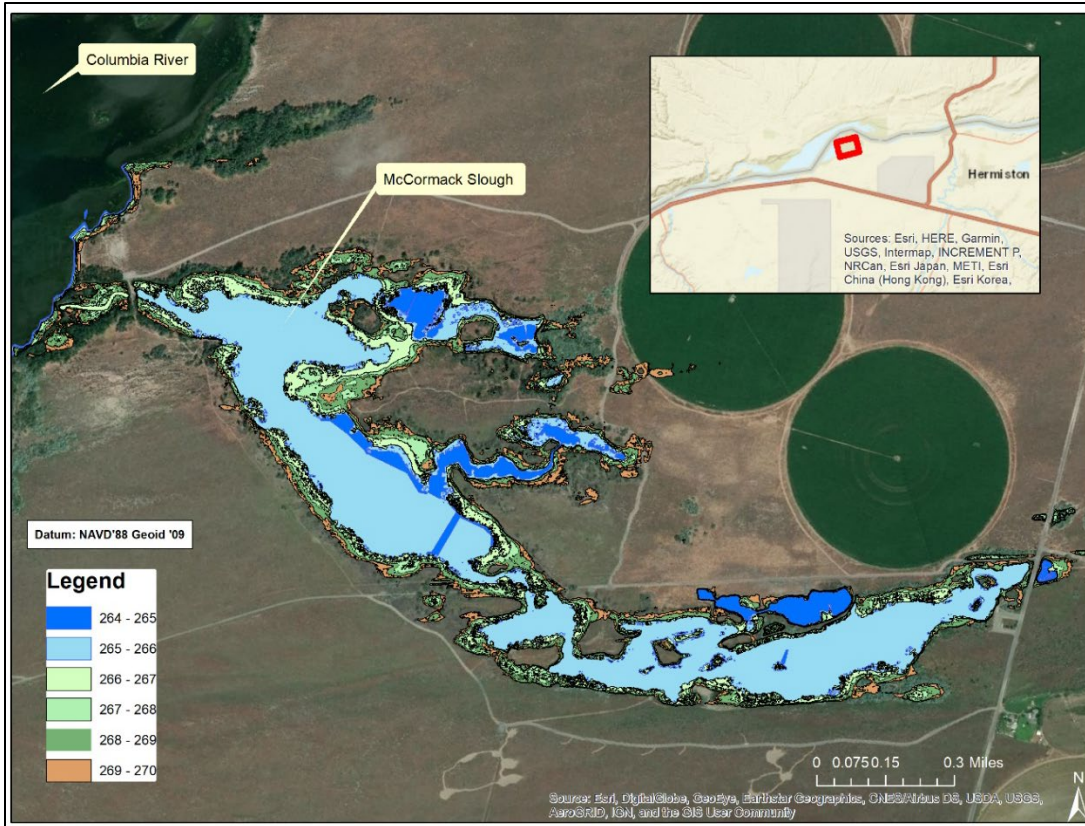
21499 Note: Legend units are feet.

21500 Downstream of The Dalles Dam, the ecosystems begin shifting from warmer, drier habitats to
21501 cooler, wetter habitats. Upland habitats downriver from Bonneville Dam vary between wet,
21502 cool forests west of the Cascade Range to oak savannahs near Vancouver, Washington, and
21503 Portland, Oregon, to coastal forests near the ocean. The river banks transition from bedrock
21504 shorelines near Bonneville Dam and the Columbia River Gorge to sandy beaches near the coast,
21505 with rock- or dirt-fill levees throughout much of the lower river. Habitat conditions associated
21506 with the levees would continue under the No Action Alternative. As described above, it is
21507 assumed that routine operations and maintenance of levees would continue and in areas that
21508 are not regularly maintained, current levels of existing erosion or degradation would continue.

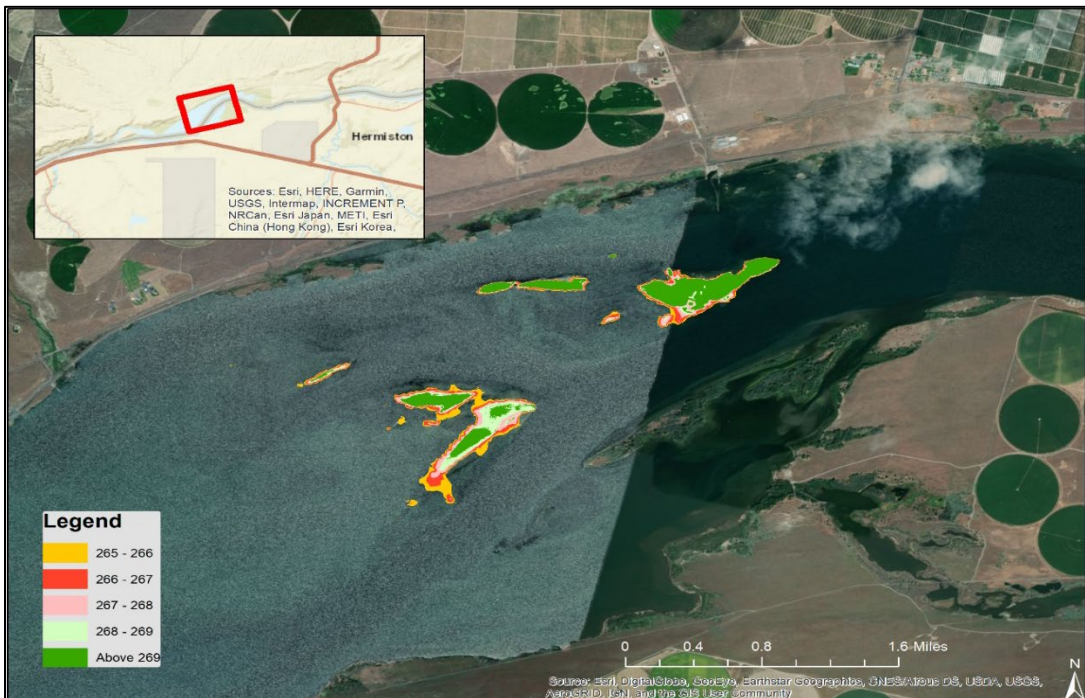
21509 Throughout Region D, USFWS, ODFW, and WDFW manage emergent herbaceous and forested
21510 and scrub-shrub wetland habitat to support fish and wildlife habitat. The No Action Alternative
21511 assumes USFWS would continue to implement management activities consistent with refuge
21512 goals and agency policies for the benefit of fish and wildlife in the lower river. As a result, it is
21513 assumed that management activities at McNary, Umatilla, Franz Joseph, Pierce, Steigerwald,
21514 Ridgefield, Julia-Butler Hansen, and Lewis and Clark National Wildlife Refuges (NWRs) would
21515 maintain habitat conditions similar to current conditions. The Umatilla NWR would continue to
21516 support valuable habitat for fish and wildlife under the No Action Alternative, and McCormick
21517 Slough on Lake Umatilla would continue to provide valuable habitat for wintering waterfowl in
21518 the Umatilla NWR Important Bird Area (IBA) (Figure 3-150). Concentrations of ducks and geese
21519 over-wintering in the study area are anticipated to continue in numbers consistent with current
21520 trends under the No Action Alternative. The Rock Creek IBA in Washington near The Dalles,
21521 Oregon, is anticipated to continue providing valuable shrub-steppe habitat for a multitude of
21522 bird species, including ash-throated flycatchers (*Myiarchus cinerascens*) and California scrub
21523 jays (*Aphelocoma californica*). Conditions in these habitat areas would remain the same under
21524 the No Action Alternative.

21525 Similarly, the Blalock Islands and surrounding low-lying sand and gravel bars, located between
21526 RM 272 and 277, are anticipated to continue providing suitable habitat for breeding Caspian
21527 terns, gulls, and other waterbirds under the No Action Alternative (Figure 3-151 and
21528 Figure 3-152).

21529 Under the No Action Alternative, no management activities would occur to modify or change
21530 the suitability of habitats in the Lake Umatilla study area to support or preclude breeding
21531 habitat. Currently, John Day Dam is managed to maintain water surface elevations in Lake
21532 Umatilla at elevations between 257.0 and 268.0 feet NGVD29 (NAVD88) with normal pool
21533 operations changing seasonally. The normal operating range for Lake Umatilla is between 262.5
21534 - 265.0 feet in October, 262.0 - 266.5 feet November through December, 262.0 - 265.0 feet
21535 January 1 - March 14, 262.5 – 265.0 feet March 15 – April 9, and between 262.5 and 264.0 feet
21536 April 10 – September 30. Slight deviations from these levels could occur occasionally (e.g., to
21537 meet navigation requirements, or hydropower needs). John Day Dam operates for flood risk
21538 management and Lake Umatilla will draft to as low as 257.0 feet and may fill to a maximum
21539 pool of 268.0 feet during flood operations. Under the No Action Alternative operations,
21540 approximately 3.6 acres of suitable habitat is available in the Blalock Islands complex during the
21541 breeding season for nesting Caspian tern. The total acreage available for nesting terns does not
21542 occur as one colony site but is instead fragmented between several low-lying islands with no or
21543 very limited vegetation.



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 21545 **Figure 3-150. McCormack Slough in the Umatilla National Wildlife Refuge at River Mile 273**
 21546 Note: The slough is a shallow water habitat environment that is part of the USFWS-managed Umatilla NWR
 21547 downstream of McNary Dam. The legend units are feet NAVD88.



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 21549 **Figure 3-151. Blalock Islands Complex in the Lake Umatilla at River Mile 273**
 21550 Note: The island complex is part of the USFWS-managed Umatilla NWR downstream of McNary Dam.

21551 As mentioned above, operations and maintenance actions at ODFW- or WDFW-managed lands
21552 and habitat for the benefit of wildlife are assumed to continue similar to current practices
21553 under the No Action Alternative. This includes Klickitat Wildlife Area near RM 180 for western
21554 pond turtle (*Actinemys marmorata*) and Sondino Ponds in Washington. As a result of these
21555 collective actions, it is assumed that wildlife concentrations and use of habitats in the lower
21556 Columbia River would not change from current conditions in response to the No Action
21557 Alternative.

21558 The Corps currently implements management activities at and downstream of John Day Dam,
21559 The Dalles Dam, and Bonneville Dam to reduce avian predation on juvenile salmonids by gulls
21560 and terns. These activities include the maintenance of avian wires spanning the river
21561 (effectively bank to bank), in an effort to minimize large concentrations of birds congregating at
21562 juvenile bypass outfalls where they can more easily prey upon juveniles exiting the bypass
21563 systems. The Corps, with support from USFWS and U.S. Department of Agriculture Animal and
21564 Plant Health Inspection Service Wildlife Services, also implement management activities to limit
21565 the availability of nesting habitat for Caspian tern and double-crested cormorant
21566 (*Phalacrocorax auratus*) at East Sand Island at RM 5.5. These management activities include
21567 hazing birds from areas outside of a designated colony area, for example, limiting the
21568 availability of habitat for Caspian tern to 1.0 acre through habitat management by removing
21569 unwanted vegetation and installing dissuasion materials to delineate a 1.0-acre breeding
21570 colony. Under the No Action Alternative, management activities would continue and include
21571 coordinating with the USFWS for authorization to haze birds from nesting habitat outside the
21572 managed 1 acre, and collect eggs in order to limit nest establishment. These management
21573 activities at East Sand Island in the Columbia River estuary, which are outlined in the Caspian
21574 Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary EIS
21575 (Corps 2014) and Double-crested Cormorant Management Plan to Reduce Predation of Juvenile
21576 Salmonids in the Columbia River Estuary EIS (Corps 2015), would continue. The effects of these
21577 management actions on Caspian terns and Double-crested cormorants are to limit reproductive
21578 success, manage population growth, and specific to Terns, relocate some of the nesting
21579 population to habitat outside the Columbia River Basin.

21580 In an effort to curb pinniped (seal and sea lion) predation on ESA-listed salmonids, regional fish
21581 and wildlife agencies implement management actions to selectively remove (lethally and non-
21582 lethally) sea lions observed repeatedly feeding on salmon and steelhead below Bonneville Dam
21583 on the Columbia River. Between 2008 and 2016, a total of 144 individual California sea lions
21584 were lethally removed (euthanized) from waters below Bonneville Dam, 15 animals were
21585 relocated to zoos or aquariums, and 2 died in traps. These actions are expected to continue
21586 under the No Action Alternative, with increasing numbers of sea lions lethally removed from
21587 the population as capacity in zoos or aquariums declines.



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Figure 3-152. Caspian Tern Nesting Colonies in 2018 at Middle and Long Islands in the Blalock Islands Complex

Source: Bird Research Northwest (2019)

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The Oregon Department of Fish and Wildlife (ODFW) implements management activities for pinnipeds (seal and sea lion) in the Columbia River estuary downstream of Bonneville Dam. In an effort to curb pinniped predation on ESA-listed salmonids, regional fish and wildlife agencies implement management actions to selectively remove (lethally and non-lethally) sea lions observed frequently feeding on salmon and steelhead below Bonneville Dam up to The Dalles Dam. For example, Bonneville's F&W Program has funded a non-lethal sea lion predation deterrence and monitoring project with the Columbia River Inter-Tribal Fish Commission (CRITFC) since 2008. Each year, Bonneville funds CRITFC to conduct boat-based hazing of California and Steller sea lions below Bonneville Dam. The CRITFC project investigates techniques to evaluate the effectiveness of these hazing efforts and also enumerates sea lion abundance and estimates sea lion predation throughout the lower Columbia River. These actions are expected to continue under all alternatives.

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In this region, project partners, like WDFW, ODFW, Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of Warm Springs and U.S. Forest Service, manage wildlife mitigation properties funded through the Bonneville F&W Program for wildlife mitigation. For example, the Confederated Tribes of the Umatilla Indian Reservation secured and now manage the 8,768-acre Rainwater project, the 5,937-acre Iskulpa project, and the 2,765-acre Wanaket wildlife area located downstream of

21611 McNary Dam. Further, the 34,000-acre Pine Creek Conservation Area in Wheeler County,
21612 Oregon, is owned and managed by the Confederated Tribes of Warm Springs. In total, ongoing
21613 Bonneville F&W Program wildlife mitigation projects for Region D dams total over 107,000
21614 acres.

21615 **FLOODPLAINS**

21616 It is assumed here that the current probability of inundation for the existing active floodplains
21617 would continue under the No Action Alternative. Therefore, there would be no change in active
21618 floodplain benefits under the No Action Alternative.

21619 **SPECIAL STATUS SPECIES**

21620 Table 3-102 provides details about ESA-listed wildlife species that are known or are likely to
21621 occur in the study area. Over the 25-year period of analysis, it is assumed that those species
21622 federally listed and present in the study area will remain listed and existing regulatory and best
21623 management practices would reduce the likelihood that populations would continue declining
21624 or go extinct. It is assumed that neither grizzly bear (*Ursus arctos horribilis*) critical habitat nor
21625 the whitebark pine (*Pinus albicaulis*) would be listed and their presence and population in or
21626 near the study area would remain relatively stable.

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Table 3-102. Sensitive Species that may Occur Within the Analysis Area Boundaries

Common Name	Scientific Name	Status of Species and Critical Habitat	Habitat	Potential for Occurrence	Projects Where Species Occurs	Effects of No Action Alternative
Mammals						
Grizzly bear	<i>Ursus arctos horribilis</i>	ESA status: T CH: proposed	Relatively undisturbed mountainous, closed and open timber, mixed shrubs (alder/huckleberry), meadows, seeps, and riparian zones. Species has very large home range (50 to 300 square miles for females; 200 to 500 square miles for males), encompassing diverse forests interspersed with moist meadows and grasslands in or near mountains.	Region A: High – there are two grizzly bear populations in the Libby Dam study area: the Cabinet-Yaak and Selkirk Ecosystems. Grizzly bear are also present in areas surrounding Hungry Horse Reservoir and the South Fork Flathead and Flathead Rivers, and are known or expected to occur east of Lake Pend Oreille. Species is unlikely to occur in the study area around Lake Pend Oreille because of the generally developed nature of this area and high degree of habitat fragmentation. Critical habitat is proposed in Albeni Falls study area near Pend Oreille.	Libby Hungry Horse	Operations under No Action Alternative are not expected to adversely impact habitat or individuals using the habitat in the study area. This is based on previous consultations for grizzly bear (USFWS 2000).
Columbian white-tailed deer	<i>Odocoileus virginianus leucurus</i>	ESA status: T CH: None	Lower Columbia River bottomlands, elevations about 10 feet above sea level, open to forested.	Region D: High – high overlap between this portion of the affected area and species range.	Downstream of Bonneville	Same as existing conditions.
California sea lion	<i>Zalophus californianus</i>	ESA status: None CH: None	Coastal waters and estuaries of the West Coast.	Region D: High – numerous documented detections at Bonneville Dam and downstream.	Downstream of Bonneville, occasionally to The Dalles Dam.	Same as existing conditions.
Steller sea lion	<i>Eumetopias jubatus</i>	ESA status: None CH: None	Coastal waters and estuaries of the West Coast.	Region D. High – numerous documented detections at Bonneville Dam and downstream	Downstream of Bonneville	Same as existing conditions.
Southern Resident killer whale Distinct Population Segment	<i>Orcinus orca</i>	ESA Status: E CH: None	Pacific Ocean between Cape Flattery, Washington, and Point Sur, California.	None – does not occur in the study area but may be affected by changes in prey base (Chinook and chum).	None	Operations under No Action Alternative are not expected to adversely impact habitat or individuals using the habitat in the study area. Same as existing conditions.
Birds						
Yellow-billed cuckoo	<i>Coccyzus americanus</i>	ESA status: T CH: Proposed	Low elevation, open woodland and deciduous riparian vegetation adjacent to rivers and streams in western United States. Tall cottonwood and willow forests serve as foraging sites. Adjacent suitable, less preferred habitat includes overgrown orchards and abandoned farmland. Species requires relatively large (>49.5 acres) continuous patches of multi-layered riparian habitat for nesting. Also known to nest in early to mid-successional native riparian habitat. Proposed critical habitat does not occur in the Columbia River Basin.	Region A: Low – summering yellow-billed cuckoo range extends into the study area in Montana; however, there are no documented occurrences in the study area. Region B: None – while current range includes the study area below Albeni Falls Dam downstream of Newport, Idaho, there are no known occurrences. However, there may be transient individuals in the study area. Region C: Low – there are no known breeding populations in Oregon (Marshall, Hunter, and Contreras 2003). In Idaho there is reported breeding on the Snake River (Cavallaro 2011) in the area of Twin Falls. Region D: Low – No known breeding populations. Limited to transient individuals. Last recorded observation west of Cascade Range occurred at Sandy River delta in Oregon in 2009, 2010, and 2012 (Withgott 2012; USFWS 2013).	Study area is within the range of yellow-billed cuckoo.	Operations under No Action Alternative are not expected to adversely impact habitat or individuals using the habitat in the study area.
Bald eagle and golden eagle	<i>Haliaeetus leucocephalus</i> <i>Aquila chrysaetos</i>	ESA Status: none CH: none Bald and Golden Eagle Protection Act	Bald eagle roost and nest in large trees adjacent to the river shoreline. Golden eagle roost and nest high on rocky cliffs and talus.	Regions A, B, C, and D. Year-long residents breeding from late January through August with peak activity in March through July. They may also move downslope for wintering or upslope after the breeding season (Polite and Pratt 1999; Technology Associates 2009).	Throughout the study area.	Operations under No Action Alternative are not expected to adversely impact habitat or individuals using the habitat in the study area.
Streaked horned lark	<i>Eremophila alpestris strigata</i>	ESA status: T CH: Designated	Dredge material disposal sites, open grasslands, dunes, sandy beaches.	Region D: High – high overlap between this portion of the affected area and species range.	Downstream of Bonneville	Same as existing conditions.

Common Name	Scientific Name	Status of Species and Critical Habitat	Habitat	Potential for Occurrence	Projects Where Species Occurs	Effects of No Action Alternative
Plants						
Ute ladies'-tresses	<i>Spiranthes diluvialis</i>	ESA status: T CH: None	Cobbly sand, shingly sand, gravelly sand, or sandy loam of wet meadows, stream or lake margins, and abandoned stream meanders, riparian sandbars, and sub-irrigated springs and seeps.	Region B: High – they occur at higher elevations, along riverine areas, and do well within disturbed areas.	Grand Coulee Chief Joseph	Operations under No Action Alternative are not expected to adversely impact habitat or individuals using the habitat in the study area. This is based on previous consultations for Ute ladies'-tresses (USFWS 2000).

21628 Note: C = Candidate for listing; CH = Designated Critical Habitat; E = Endangered; PT = Proposed for listing as Threatened; T = Threatened.

21629 **SUMMARY OF EFFECTS**

21630 Under the No Action Alternative, current mitigation measures, such as juvenile fish transport,
21631 salmon and steelhead hatchery production, and avian predation control, would continue,
21632 affecting prey availability in the lower Columbia River. Water and sediment quality conditions
21633 (water temperatures, thermal conditions, nutrients, and pollutants) and their effects on wildlife
21634 would continue under the No Action Alternative. Patterns of erosion and subsequent sediment
21635 accumulation behind the Federal dams would continue, trapping potential contamination
21636 behind the dams, leading to bioaccumulation in benthic and aquatic organisms. Furthermore,
21637 trapping sediments behind the dams disrupts natural sediment transport processes,
21638 increasingly resulting in downstream reaches becoming starved of sediment. As a consequence
21639 of this, accretion processes in the lower river are diminished, leading to loss of wetlands and
21640 mudflats. These patterns are expected to continue under the No Action Alternative. Ongoing
21641 actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue,
21642 including protection, mitigation, and enhancement of wildlife habitat as discussed in Section
21643 5.2.1.

21644 As dam operations, and the frequency, timing, depth, and duration of flows throughout the
21645 Columbia River Basin, would be similar to existing conditions, the driving ecological and
21646 anthropogenic processes that currently influence wildlife habitat and populations would remain
21647 largely consistent over the 25-year period of analysis. Because the current probability of
21648 inundation for the existing active floodplains would continue under the No Action Alternative,
21649 there would be no change in floodplain benefits. Riparian vegetation that is dependent on the
21650 natural riverine freshet, such as cottonwoods, would continue to decline in some areas where
21651 the hydrology of the floodplains has been altered. Unless otherwise described below, the
21652 amount and type of vegetation wildlife habitat and wildlife species present under the No Action
21653 Alternative would remain consistent with that described in Section 3.6.2 (Affected
21654 Environment).

21655 Under the No Action Alternative, wildlife would continue to be influenced by availability of
21656 habitat, natural processes including fire and human-wildlife interaction through recreation,
21657 including hunting. Where human disturbance increases, wildlife may experience adverse effects
21658 and temporarily or permanently relocate to alternative habitat areas with little or no
21659 disturbance. Conversely, wildlife would experience beneficial effects from implementation of
21660 habitat restoration actions to meet local, state, and regional habitat objectives. The rich
21661 diversity and abundance of wildlife throughout the Columbia River Basin would continue in a
21662 manner similar to existing conditions described in Section 3.13.1, as would the seasonal
21663 fluctuations in wildlife numbers and diversity resulting from the presence of large numbers of
21664 migratory wildlife. Mammals, migratory game birds, reptiles and amphibians, and terrestrial
21665 and aquatic invertebrates would remain abundant in the study area. Winter conditions that
21666 influence predator/prey relationships are not expected to change from current conditions, and
21667 existing patterns of predation would continue.

21668 **3.6.3.3 Multiple Objective Alternative 1**

21669 Chapter 2, *Alternatives*, contains a description of how the CRS would be operated under MO1.
21670 A full description of the alternative can be found in Section 2.4.3.

21671 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

21672 Three operational measures would be implemented at Libby Dam, which differ from current
21673 operations as described under the No Action Alternative: the *Modified Draft at Libby*, *December*
21674 *Libby Target Elevation*, and *Sliding Scale at Libby and Hungry Horse* measures. Refer to Chapter
21675 2, *Alternatives*, and Table 2-3 for a description of these measures.

21676 During spring months and the early part of the growing season, water levels under the *Modified*
21677 *Draft at Libby* measure would drop approximately 2.5 feet below average to account for deeper
21678 drafts. Changes in a high- or low-water year may have another effect. The increase in annual
21679 peak outflow from Libby Dam has a small impact on peak flows downstream in the Kootenai
21680 River; however, decreased outflow in May generally translates to a decrease in freshet peaks.
21681 Following an increase in water surface elevations in February and March, water surface
21682 elevations in the Kootenai River would decrease in April and May by approximately 1 foot in
21683 average years from the implementation of the *Modified Draft at Libby* measure under MO1.
21684 This change in water surface elevations would potentially alter wetland habitat types
21685 throughout the Kootenai River.

21686 By implementing the *December Libby Target Elevation* measure, Libby Dam would be operated
21687 to reduce the frequency of overdrafting the reservoir when years are drier than initially forecast
21688 by establishing a new end-of-December draft target of 2,420 feet NGVD29 (NAVD88), an
21689 increase of 9 feet from the No Action Alternative. This would allow for less variability in pool
21690 elevation as opposed to the wider range of December elevations under the No Action
21691 Alternative. As a result of this new draft target under the *December Libby Target Elevation*
21692 measure, winter water levels in the reservoir would increase, peaking in January when the pool
21693 elevation would be 7 feet higher than the No Action Alternative. The primary habitat affected
21694 by the new end-of-December water surface elevation would be the barren area, or barren
21695 zone.² Implementing the *December Libby Target Elevation* measure would reduce the spatial
21696 extent of the barren area by approximately 9 (vertical) feet around the reservoir during most
21697 years, increasing the wetted area during the winter months. The area of land between 2,411
21698 feet and 2,420 feet would not freeze as in previous years under the No Action Alternative,
21699 allowing for potential vegetation establishment in the spring as a result of increased viability of
21700 seeds that do not freeze over the winter.

² A change in the elevation is discussed as a vertical change in elevation and it is recognized that this change does not translate into a 1:1 relationship with the area impacted. For example, an elevation change of 9 feet does not correspond to a horizontal change of 9 feet. Because terrain below the water surface of the reservoir was not available for this analysis, the area impacted by a vertical change in elevation was not calculated and it is therefore unknown how much area would be directly impacted by changing pool elevations. However, the effects of this change can be assessed qualitatively, as described in the narrative above.

- 21701 The *December Libby Target Elevation* measure would provide additional stability to beaver
21702 (*Castor canadensis*) colonies on the lower Kootenai River due to decreased variability in
21703 December flows. The beaver is considered an “ecosystem engineer,” constructing dams that
21704 impound water and increase, diversify, and support wetland vegetation communities (Wright,
21705 Jones, and Flecker 2002). The *December Libby Target Elevation* measure would have trickle-
21706 down effects immediately benefiting aquatic wildlife and herbivores, such as amphibians and
21707 white-tailed deer (not Columbia White-tailed Deer).
- 21708 Operational changes at Libby Dam under MO1 can be seen throughout the Kootenai River
21709 system during most months but are increasingly diluted from tributary inputs downstream of
21710 the dam from the Fisher, Yaak, and Moyie Rivers. The largest downstream changes occur in
21711 December when outflows decrease by 4 to 5 kcfs, rapidly followed by an increase in outflows in
21712 February of up to 3.3 kcfs. Operational changes would cause water levels to fluctuate at the
21713 Kootenai Falls Wildlife Management Area (RM 202) from 1.3 feet lower in December (relative
21714 to the No Action Alternative) to an increase of 1.2 feet in February and March. Water level
21715 fluctuations in March would inundate narrow bands of emergent vegetation along the Kootenai
21716 River shoreline adjacent to the wildlife management area at the start of the growing season.
21717 However, the wildlife managed at Kootenai Falls Wildlife Refuge are primarily upland species,
21718 including mule deer, bighorn sheep, and white-tailed deer (MFWP 2016). Under MO1, changes
21719 to wetland vegetation from the proposed operations would not have measurable effects to
21720 species in this area.
- 21721 The *Sliding Scale at Libby and Hungry Horse* measure would increase growth and expand
21722 wetlands where they occur at tributary confluences, like the Tobacco River, especially late in
21723 the summer months when conditions for wildlife are generally warmer and drier. The
21724 biologically rich transition zone between emergent herbaceous, and forested and scrub-shrub
21725 wetlands would shift laterally, increasing the overall spatial extent of wetland habitats in the
21726 immediate vicinity of Lake Koocanusa relative to the amount of wetland habitats that occur
21727 under the No Action Alternative.
- 21728 Higher water surface elevations within Lake Koocanusa from the *Sliding Scale at Libby and*
21729 *Hungry Horse* measure would also increase the area of open-water habitat and reduce the
21730 barren area, and therefore decrease the rates of predation of small wildlife. Higher water levels
21731 during summer months (June through September) would increase the inundation levels within
21732 adjacent wetlands during the growing season, resulting in a reduction of existing emergent
21733 wetland vegetation or a transition in plant communities to species that can tolerate patterns of
21734 regular inundation. These changes would impact nesting waterfowl by reducing the amount of
21735 woody vegetation along the shoreline available during the breeding season.
- 21736 With spring and summer, water levels in the Kootenai River are typically several inches lower
21737 compared to the No Action Alternative, MO1 operational changes at Libby Dam would likely
21738 cause small habitat changes, such as drying of shallow backwater areas. This could affect
21739 wildlife such as the western toad by causing immotile amphibian eggs to desiccate.

21740 Aquatic invertebrates, like caddisflies and stoneflies, would experience similar interruptions in
21741 life cycle, which could lead to changes in the food web and a corresponding decrease in food
21742 availability throughout the area thereby affecting wildlife species that feed on them (See
21743 Section 3.5, *Aquatic Habitats, Aquatic Invertebrates, and Fish*).

21744 Under MO1, Hungry Horse reservoir would experience a deeper drawdown during most
21745 months that would expose more of the barren area surrounding the reservoir and would create
21746 higher predation risk for wildlife. During late fall and winter, the barren area would not be
21747 noticeable to wildlife, as the area is typically covered in snow and the reservoir freezes over for
21748 many months. During the spring and early fall, when the barren area is exposed and would be
21749 larger than that which occurs under the No Action Alternative, wildlife would be at increased
21750 risk of predation as they traverse the area to reach the reservoir. This would be a minor effect
21751 on wildlife.

21752 The increased barren area would have negligible (if any) impact on birds in the area. The time
21753 period when the reservoir would experience the greatest change under MO1 is during the
21754 winter months when there is little bird activity at Hungry Horse.

21755 Downstream of Hungry Horse Reservoir, along the South Fork Flathead River, the effects from
21756 implementing MO1 would be negligible. The changes in water level are typically less than 0.2
21757 foot (approximately 2.4 inches). This marginal change would not alter floodplain function,
21758 wetland habitats, vegetation communities, or wildlife populations in the Hungry Horse study
21759 area compared to the No Action Alternative. Current trends associated with plant communities,
21760 including willows and cottonwoods, are expected to continue similar to the trends described
21761 under the No Action Alternative. While there would be a small increase in water surface
21762 elevation in the Flathead River downstream of Hungry Horse Dam in August and September due
21763 to increased outflow for water supply through implementation of the *Hungry Horse Additional*
21764 *Water Supply* measure, the effects of this increased water on existing habitats would be
21765 negligible. In the Flathead River, effects would be even less pronounced and would become
21766 increasingly diluted downstream.

21767 Under MO1, no structural changes would be implemented at Albeni Falls Dam or within the
21768 Albeni Falls study area. Similarly, no changes would be made to Albeni Falls Dam operations in
21769 most water years. Results from H&H modeling and analysis show that higher flow periods in the
21770 winter and spring would be slightly lower due to changes at Hungry Horse, resulting in slightly
21771 lower water levels compared to the No Action Alternative. The differences in monthly water
21772 surface elevations (less than 6 inches) is typically within the expected range of natural
21773 variability. Thus, negligible impacts to floodplains are expected from the implementation of this
21774 proposed measure. Because the annual average probability of inundation would remain
21775 unchanged from current conditions, negligible impacts to floodplains are expected.

21776 In most years, implementation of MO1 would have no effect on vegetation or wildlife in the
21777 Albeni Falls study area and conditions would remain unchanged from the No Action Alternative.
21778 However, during high-flow conditions, water surface elevations downstream of the dam would
21779 decrease by as much as 5 inches in November relative to patterns observed under the No

21780 Action Alternative. Despite lower water surface elevations, implementing the *Hungry Horse*
21781 *Additional Water Supply* measure under MO1 is not expected to alter the type, location, or
21782 abundance of vegetation, floodplain function, wildlife habitat, or wildlife populations in the
21783 Albeni Falls Dam study area. Because river levels would drop less than 6 inches during high
21784 water events outside of the growing season, it is highly unlikely that habitats would functionally
21785 change in response to the *Hungry Horse Additional Water Supply* measure. Consequently, no
21786 effects to wildlife populations are expected from the implementation of this proposed
21787 measure.

21788 The operational changes from implementing MO1 would result in small changes in the Lake
21789 Kootenai study area and would therefore have negligible effects on wildlife populations.
21790 Similarly, MO1 is not expected to impact any wildlife populations downstream of Libby, Hungry
21791 Horse, or Albeni Falls Dams. Similar to the No Action Alternative, trends of reduced riparian
21792 vegetation establishment due to higher winter flows would be expected to continue, as
21793 observed in the Flathead River study area. The gradual loss of deciduous woody plant
21794 communities and conversion to coniferous uplands and forested and scrub-shrub wetlands
21795 would lead to a loss of biodiversity and degraded ecosystem function in the Libby Dam study
21796 area (Kootenai Tribe of Idaho [KTOI] 2013). Despite these changes, it is anticipated that habitat
21797 conditions in Region A and sections of the Kootenai, Flathead, and Pend Oreille Rivers
21798 downstream from dams would stabilize after several years under MO1. Efforts to restore black
21799 cottonwood galleries, as described under the No Action Alternative, would continue.

21800 The operational changes at Libby Dam from MO1 would also be evident in downstream reaches
21801 of the Columbia River, as discussed in the Regions B and D sections below.

21802 In regard to potential effects in Canada, the effects to vegetation and wildlife resources and
21803 their habitats under MO1 are expected to be similar to the effects described for the United
21804 States portion of Region A.

21805 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

21806 At Grand Coulee Dam, there are five operational measures under MO1 that have the potential
21807 to impact habitats, floodplains, and wildlife populations in the study area: the *Update System*
21808 *FRM Calculation*, *Planned Draft Rate at Grand Coulee*, *Grand Coulee Maintenance Operations*,
21809 *Winter System FRM Space*, and *Lake Roosevelt Additional Water Supply* measures. Collectively,
21810 these measures influence water surface elevations in Lake Roosevelt and downstream reaches
21811 of the Columbia River, as well as the outflow from Grand Coulee Dam, resulting in changes to
21812 the quantity, quality, and distribution of habitats in the study area. Changes to wildlife habitats
21813 have a corresponding effect on wildlife populations in the study area.

21814 The *Winter System FRM Space* measure would decrease water surface elevations immediately
21815 upstream of the dam in Lake Roosevelt by approximately 5 to 6 feet during the winter months
21816 (January through March, with less than a foot difference in April) in most years, when
21817 compared to the No Action Alternative. The effects of this decrease would be evident
21818 throughout the Lake Roosevelt system all the way to U.S.-Canada border, but decrease to a loss

21819 of approximately 3 feet in elevation (or depth) farther upstream. Such a large decrease in water
21820 surface elevation across the study area would impact wildlife habitat similar to the changes
21821 expected at Libby Dam. The frequency and duration of drying conditions would increase for
21822 areas with emergent herbaceous and forested and scrub-shrub wetlands, and these habitats
21823 would transition into upland habitats, or plant communities in these habitats would transition
21824 to predominantly species more tolerant of dry conditions. This would change plant composition
21825 and distribution, or reduce the overall quantity of wetland acreage.

21826 The *Lake Roosevelt Additional Water Supply* measure would increase the exposure time of the
21827 barren area around the perimeter of Lake Roosevelt in response to decreased water surface
21828 elevations in the winter and spring months. Because the growing season (April through
21829 October) overlaps with decreased water surface elevations in Lake Roosevelt, changes to
21830 growing conditions and plant communities would result from implementation of this measure.

21831 These changes to habitat are expected to reduce overwintering habitats for wintering
21832 waterfowl and diving ducks, as well as wildlife populations supported by wetland habitats in the
21833 Grand Coulee Dam study area. The gradual loss of deciduous woody plant communities and
21834 potential conversion to upland plant communities would lead to a loss of biodiversity and
21835 degraded ecosystem function. However, despite these changes it is anticipated that habitat
21836 conditions in Region B and sections of the Columbia River downstream from Chief Joseph Dam
21837 would stabilize after several years under MO1.

21838 Under the *Planned Draft Rate at Grand Coulee* and *Winter System FRM Space* measures, lower
21839 water levels in Lake Roosevelt would persist longer into the spring months compared to the No
21840 Action Alternative. As a result, emergent herbaceous and forested and scrub-shrub wetlands
21841 would transition to drier habitat types and the composition of plants would shift to primarily
21842 species more tolerant of drier conditions, thereby reducing the overall quantity, distribution, or
21843 functional quality of wetland habitats in the study area. As a result, these changes would
21844 negatively impact the health and development of forested and scrub-shrub wetlands where
21845 gallery forests or tree stands, such as stands of black cottonwood (*Populus trichocarpa*), are the
21846 predominant tree species supporting bald eagle nests in the study area. Shallow backwater
21847 habitat would become intermittently dry as water surface elevations decrease, causing
21848 immotile amphibian eggs, like those of the western toad, to desiccate. Because of the lack of
21849 vegetation or other habitat cover in the barren zone, small mammals (i.e., mice, voles, and
21850 shrews) would experience increased rates of predation, as they would be more susceptible to
21851 predators foraging along the reservoir shoreline. Areas that establish as emergent herbaceous
21852 wetlands would provide increased protection for some animals, as well as increased overall
21853 biodiversity and productivity along the reservoir.

21854 Changes to water levels or fluctuating water conditions in Lake Roosevelt in response to the
21855 *Winter System FRM Space* measure would impact foraging behaviors of diving ducks and other
21856 waterfowl by changing the quality and quantity of open-water habitat and shallow-water areas
21857 for foraging. The common loon (*Gavia immer*) overwinters in Lake Roosevelt, foraging in open-
21858 water habitats and shallow-water areas with emergent or submerged vegetation from October

21859 through March. When water surface elevations are lower, the availability of open-water habitat
21860 with suitable foraging material would be reduced. When shallow-water areas become exposed,
21861 emergent vegetation would no longer be available as forage, decreasing overwintering habitat
21862 conditions for wintering waterfowl.

21863 Decreased water surface elevations in Lake Roosevelt associated with MO1 would influence
21864 predator populations, as well as ungulate populations in the Grand Coulee Dam study area.
21865 Increasing the barren area during winter under lower water surface elevations would impact
21866 ungulate populations, such as bighorn sheep. More barren area habitat would provide
21867 increased area for mountain lion to hunt and kill prey animals, which could result in higher
21868 predation rates on the local ungulate (i.e., elk, deer, and bighorn sheep) population.

21869 Upstream of Grand Coulee Dam, the decreased water surface elevations during the winter and
21870 early growing seasons would impact plant communities and wetland habitats adjacent to the
21871 shoreline, any changes in those habitats (e.g., changed plant composition or distribution, or
21872 reduction in overall quantity of wetlands) would impact foraging and sheltering habitats,
21873 resulting in effects to migratory wildlife, such as birds or large mammals, utilizing these areas.

21874 The operational changes at Grand Coulee Dam under MO1 are also evident throughout the
21875 Columbia River System, as discussed below in Region D. In regard to potential effects in Canada,
21876 the effects to vegetation and wildlife resources and their habitats under MO1 are expected to
21877 be similar to the effects described for the United States portion of Region B.

21878 At Chief Joseph Dam, MO1 includes the *Chief Joseph Dam Project Additional Water Supply*
21879 measure, which diverts up to 9,600 acre-feet of water from the Columbia River during the
21880 irrigation season (April through October) to support irrigation on authorized lands downstream
21881 from the dam. The growing season in the Chief Joseph study area is from April to November;
21882 the diversion directly overlaps this time period. The measure contributes to decrease in river
21883 flow river flow below Chief Joseph Dam. The loss of this water from the river system is relatively
21884 small compared to the much larger changes in flow resulting from the *Lake Roosevelt Additional*
21885 *Water Supply* measure at Grand Coulee. As a result, there are no noticeable effects on water
21886 surface elevations immediately downstream from Chief Joseph Dam, related to the *Chief Joseph*
21887 *Dam Project Additional Water Supply* measure, and the measure is not expected to result in a
21888 measurable impact to habitats or wildlife populations upstream or downstream of Chief Joseph
21889 Dam. Wildlife mitigation actions would continue to be consistent with actions described under
21890 the No Action Alternative.

21891 Changes in water levels at the upstream ends of Chief Joseph Reservoir and the other projects
21892 through the middle Columbia River reach (Wells Dam, Priest Rapids Dam, etc.) would occur as a
21893 result of the changes in outflow from Grand Coulee Dam. The same is true for the Hanford
21894 Reach below Priest Rapids Dam. Flow and water levels are generally increased in December as a
21895 result of the *Winter System FRM Space* measure, and decreased from February through
21896 September, mostly from the *Lake Roosevelt Additional Water Supply* measure. Both the
21897 increase in December water levels and the decrease later in the spring through the summer are
21898 typically 0.5 foot or less. These changes would be evident in most of the free-flowing Hanford

21899 Reach downstream of Priest Rapids Dam, but are negligible within most of the reservoirs
21900 between Grand Coulee and Priest Rapids. These changes are expected to have a negligible
21901 effect on wildlife. Reaches of the Columbia River upriver from McNary Dam (i.e., the Hanford
21902 Reach) are affected by the *Planned Draft Rate at Grand Coulee* and *Winter System FRM Space*
21903 measures at Grand Coulee Dam resulting in changes to the quantity, quality, and distribution of
21904 habitats in the study area.

21905 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
21906 **HARBOR DAMS**

21907 Under MO1, the *Dworshak Temperature Control* measure would result in changes to
21908 Dworshak Reservoir elevation from June through September. Water levels are consistently
21909 lower June 20 through August 1, typically between 3 and 8 feet. From August 1 to August 31,
21910 draft slows dramatically and the deeper reservoir transitions to being about 10 feet higher by
21911 August 31 in most years compared to the No Action Alternative. For the first half of September
21912 the water levels are about 10 feet higher compared to the No Action Alternative, but then
21913 match the No Action Alternative by September 30 at 1,520 feet NGVD29 (NAVD88).

21914 This measure would result in changes to the quantity, quality, and distribution of habitats in the
21915 study area. Changes to wildlife habitats have a corresponding effect on wildlife populations in
21916 the study area. Lower water levels in June, July, and August would cause amphibian eggs along
21917 the shoreline to dry out and would create a larger barren area for small mammals to cross.

21918 Emergent vegetation would establish itself in some portions of the barren area during the early
21919 part of the growing season (April through June), transitioning these areas into emergent
21920 herbaceous wetland habitats.

21921 Water levels on the Clearwater River downstream from Dworshak Dam would be more than 1
21922 foot higher in most years in late June and mid-September, about 0.5 foot higher in July, and as
21923 much as 2 feet lower in August, associated with the changes in water surface elevations
21924 following increased outflow from the *Modified Dworshak Summer Draft* measure. This change
21925 would diminish to zero at the downstream end of the reach, within the influence of the Lower
21926 Granite Reservoir. However, this change would be similar to the natural variability of flows
21927 observed under the No Action Alternative. Forested and scrub-shrub wetlands in low-lying
21928 areas along the Clearwater River would experience slightly prolonged inundation into the early
21929 summer months (June and July) following implementation of the *Modified Dworshak Summer*
21930 *Draft* measure. While the increase in water surface elevation is marginal, it would be sufficient
21931 to inundate shallow off-channel habitat or forested and scrub-shrub wetlands.

21932 Because of the lack of vegetation or other habitat cover in the barren zone, small mammals
21933 (i.e., mice, voles, and shrews) would experience increased rates of predation, as they would be
21934 more susceptible to predators foraging along the reservoir shoreline. Areas that establish as
21935 emergent herbaceous wetlands would provide increased protection for some animals, as well
21936 as increasing overall biodiversity and productivity along the reservoir. Ground-nesting birds
21937 would not be affected by operational changes at Dworshak Dam that influence pool elevations

21938 because the shorelines around the reservoir are steeply sloped and preclude suitable nesting
21939 habitat for birds. Similarly, there are no islands in the reservoir that support breeding or nesting
21940 habitat under the No Action Alternative and no new or additional island habitat would be
21941 exposed under MO1. As a result, MO1 is not expected to result in changes to accessibility to
21942 prey resources or foraging habitat for fish-eating birds, bald eagles, diving ducks, or other
21943 waterbirds. Changes in water surface elevations and outflow from Dworshak Dam are
21944 successively diluted in the Clearwater River downstream from its confluence with the lower
21945 Snake River. Any changes in operations at Dworshak Dam are not measurable in lower Snake
21946 River. Consequently, there would be no anticipated changes to shoreline habitats for ground-
21947 nesting birds or increased inundation of wetland habitats to support amphibians under MO1 as
21948 compared to the No Action Alternative.

21949 Under MO1, the reservoir elevations at the four lower Snake River dams would differ from
21950 those of the No Action Alternative during the MOP season from April 3 through August 31 due
21951 to the *Increased Forebay Range Flexibility* measure. At each project, the measure would
21952 increase the MOP range from 1.0 feet under the No Action Alternative to 1.5 feet under MO1.
21953 There would be no changes beyond the No Action Alternative for the rest of the year.
21954 Therefore, the effects to floodplains, wildlife, and vegetation along the lower Snake River would
21955 be similar to the No Action Alternative.

21956 This measure would therefore increase the quantity, quality, and distribution of wetland
21957 habitats in the Lower Snake River. Emergent herbaceous wetland may become established in
21958 new areas where water depth and inundation patterns support the establishment of wetland
21959 vegetation and soil conditions. This effect would be negligible. There would be no loss or
21960 reduction in the quality and distribution of existing emergent herbaceous and forested scrub-
21961 shrub wetlands under MO1 when compared to the No Action Alternative. Existing wetlands
21962 would continue to be productive habitats supporting breeding amphibians, reptiles, mammals,
21963 and birds during the spring and summer breeding season.

21964 The overall distribution in quantity of invasive species in Region C would remain similar to the
21965 No Action Alternative. Where no management efforts are implemented, invasive species are
21966 expected to persist under the MO1 similar to the No Action Alternative.

21967 Inundation would support critical temperature and moisture thresholds for breeding
21968 amphibians when tadpoles are emerging from eggs. For example, the western toad (*Anaxyrus*
21969 *boreas*) breeds in pools or slow-moving rivers in Montana and Idaho from early May to late
21970 June, tadpoles are generally present from late May to early September. The northern leopard
21971 frog (*Lithobates pipiens*) breeds slightly later in forested and scrub-shrub wetlands and riparian
21972 areas starting in June and ending in September (WDFW 2015). Increasing the quantity and
21973 quality of wetted areas during the breeding season would support increased reproductive
21974 success and overall fecundity for species susceptible to minor changes in water availability
21975 when compared to the No Action Alternative.

21976 **Region D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

21977 Under MO1, there would be no changes to the reservoir elevations at McNary Dam, The Dalles
21978 Dam, or Bonneville Dam. At John Day Dam, the *Predator Disruption Operations* and *Increase*
21979 *Forebay Range Flexibility* measures relate to reservoir operating range. The range in April and
21980 May is due to the *Predator Disruption Operations* measure; the range in June through
21981 September is due to the *Increased Forebay Range Flexibility* measure. The April - May pool
21982 elevations would be approximately 1.0 to 1.5 feet higher than the No Action Alternative.

21983 There are no operational changes at McNary Dam that would influence habitat conditions.
21984 While water levels in the Yakima River delta would decrease by approximately 1.5 inches in
21985 spring and summer, these changes would also be within the range of natural variability, and
21986 daily fluctuations would be similar to the No Action Alternative. Therefore, minor changes to
21987 spring and summer water levels would have no effect on vegetation establishment or mudflat
21988 exposure. Furthermore, because habitat conditions are not expected to change, there would be
21989 no measurable effects on wildlife populations using these habitats. As a result, the changes
21990 observed in the H&H model in December for MO1 would have no effect on wildlife populations
21991 or their habitats. Flowering rush would continue to establish in exposed mudflats and shallow-
21992 water areas similar to the No Action Alternative.

21993 Within the mainstem of the Columbia River, water surface elevations in the river are expected
21994 to change by approximately 1 foot above the confluence of the Snake and Columbia Rivers.
21995 These changes would result in negligibly wetter conditions than the No Action Alternative.

21996 As described in Section 3.6.2, Affected Environment, and the No Action Alternative, there are
21997 forested and scrub-shrub and emergent herbaceous wetlands in the John Day Dam study area
21998 in Patterson Slough and McCormack Slough. Increased water surface elevations in April and
21999 May would inundate wetland habitats approximately 1.5 feet vertically, including the extensive
22000 wetland complex at the Umatilla NWR, thereby temporarily decreasing the amount of
22001 vegetated wetlands available to wildlife by approximately 40 percent in the spring and early
22002 summer. Despite this prolonged inundation, the temporary nature of inundation is not
22003 expected to result in perceptible changes to wetland habitats. Rather, the composition of plants
22004 in existing wetland habitats would likely shift to species more tolerant of prolonged inundation.
22005 In addition, emergent herbaceous wetlands may become established in new areas where water
22006 depth and inundation patterns support establishment of wetland vegetation. As a result, the
22007 quantity, quality, and distribution of emergent herbaceous and forested and scrub-shrub
22008 wetlands would not change under MO1 compared to the No Action Alternative.

22009 Existing wetlands would continue to be productive habitats, supporting breeding amphibians,
22010 reptiles, mammals, and birds during the spring and summer breeding season. These wetland
22011 habitats would continue to support regionally important migratory waterfowl overwintering in
22012 the Umatilla NWR IBA by providing forage opportunities and prey resources.

22013 Under MO1, the Franz Joseph, Pierce, Steigerwald, Ridgefield, Julia-Butler Hansen, McNary, and
22014 Lewis and Clark NWRs along the Columbia River shoreline are expected to maintain habitat

22015 conditions similar to existing conditions despite minor changes (less than 3 inches) in water
22016 surface elevations in Lake Wallula, Lake Celilo, Lake Bonneville, and downstream of Bonneville
22017 Dam. The implementation of the *Increased Forebay Range Flexibility* and *Predator Disruption*
22018 *Operations* measures would not change the quantity, quality, and distribution of wetland
22019 habitats and barren areas in Lake Umatilla.

22020 Actions currently implemented under the No Action Alternative that are expected to continue
22021 under MO1 include efforts to reduce the spread and establishment of invasive species
22022 throughout Region D. A shift in wetland plant composition in Lake Umatilla in response to
22023 implementing the *Predation Disruption Operations* measure could effectively increase the
22024 distribution of invasive species as they spread into areas where they do not occur under the No
22025 Action Alternative. As a result, the overall distribution and quantity of invasive species in Region
22026 D could increase under MO1 and reduce habitat quality for some wildlife species. Where no
22027 management efforts are implemented, invasive species are expected to persist under MO1,
22028 similar to the No Action Alternative.

22029 Between John Day and The Dalles Dams, shorelines are dominated by bedrock, sand, gravel,
22030 and sandy deposits, and upland habitats are predominantly shrub-steppe, mixed grasslands,
22031 and agricultural areas. Changes in water surface elevations under MO1 would be minor (1 to 3
22032 inches) in all water years (i.e., high-water or low-water years) and would be consistent with the
22033 natural range of variability and fluctuations from daily operations. Consequently, the quantity,
22034 quality, and distribution of these upland habitat types in Lake Celilo are not expected to deviate
22035 measurably from the No Action Alternative. For example, the Rock Creek IBA in The Dalles Dam
22036 study area would not be affected from operational measures implemented under MO1, and as
22037 a result, habitat in this area would continue supporting wildlife dependent on upland shrub-
22038 steppe habitat consistent with the No Action Alternative. For these reasons, implementation of
22039 MO1 would not result in a conversion of habitats in The Dalles Dam study area and would
22040 therefore result in no measurable effects to wildlife populations.

22041 Downstream of The Dalles Dam, shorelines transition to increased vegetation and wetland
22042 complexes, with sandy beaches near the coast. Upland habitats shift from dry shrub-steppe
22043 habitat and agricultural areas to oak savannahs and mixed conifer forests. Changes in water
22044 surface elevations in the lower Columbia River under MO1 are not expected to alter the
22045 quantity, quality, and distribution of these upland habitat types in Region D. On average, the
22046 H&H model results show minor changes to water surface elevations (1 to 3 inches) in Lake
22047 Bonneville in most water years, and these changes are assumed to be within the natural range
22048 of variability given daily fluctuations in operations. As a result, there would be negligible effects
22049 to floodplains, habitat, and wildlife in the Bonneville Dam study year across all water years.

22050 As described for the No Action Alternative, several islands in Lake Umatilla are currently
22051 available as nesting habitat to fish-eating waterbirds, such as Caspian tern, including the Blalock
22052 Islands complex in the Umatilla NWR at RM 273. The *Predator Disruption Operations* measure
22053 would inundate nesting habitat on Blalock Islands during the time of year when birds typically
22054 initiate nesting activities. The relative proportion of habitat available to nesting Caspian terns

22055 under MO1 would be reduced by approximately 72 percent and limited to 0.5 to 1.0 acre
22056 compared to the amount available under the No Action Alternative (approximately 3.6 acres).
22057 Because the *Predator Disruption Operations* measure would reduce the overall quantity of
22058 habitat in Lake Umatilla in April and May, nesting waterbirds throughout the lake would delay
22059 nest initiation until water levels dropped and nesting habitat was available in June and July or
22060 not nest. Depending on the availability of forage fish and other prey resources in June and July,
22061 consistent or long-term delays in nest initiation would decrease overall reproductive success for
22062 the colony, reducing the overall fecundity and potentially leading to a long-term reduction in
22063 the regional population. Terns that are displaced by these efforts would relocate to other
22064 islands. Some terns would relocate to islands within the Columbia River Basin and some would
22065 relocate to sites outside the Columbia River Basin. Recent studies show that regional efforts to
22066 dissuade Caspian tern nesting have led to a 44 percent decline in the number of Caspian terns
22067 nesting in the Columbia Plateau region (Collis et al. 2019). Some of this reduction is due to terns
22068 relocating to nesting sites outside the basin.

22069 Decreasing the number of juveniles in the river would decrease overall prey resources
22070 supporting a variety of wildlife populations at higher trophic levels (e.g., Caspian tern, gulls,
22071 double-crested cormorant, American white pelican, and other waterfowl) or these predators
22072 would shift their diet due to change in availability (Meyer et al. 2016). In response, it is
22073 expected that wildlife populations dependent on juvenile salmonids as a prey source would
22074 transition to other resources, or populations would relocate to other areas where prey
22075 resources are more widely available.

22076 Avian nesting habitat on Badger Island, Foundation Island, and Crescent Island would be similar
22077 to the No Action Alternative based on similar water surface elevations. Island habitats at
22078 Crescent Island and Badger Islands in the McNary Reservoir would be similar to conditions
22079 under the No Action Alternative.

22080 The distribution and acreage of wetland habitat in The Dalles Dam and John Day Dam study
22081 areas is limited under MO1, similar to the No Action Alternative, due to the proximity of
22082 highways and railroads to the shoreline.

22083 Management activities implemented at and immediately downstream of John Day Dam, The
22084 Dalles Dam, and Bonneville Dam to reduce avian predation on juvenile salmonids by gulls and
22085 terns are expected to continue under MO1. These activities include the maintenance of avian
22086 wires spanning the river and active hazing of avian predators around the dams

22087 The H&H model results indicate water surface elevations in Lake Bonneville would remain
22088 consistent with the No Action Alternative and would not result in substantive or widespread
22089 changes to wildlife populations or their habitats. In locations where ODFW or WDFW manage
22090 wetland habitats for wildlife, operations and maintenance actions under MO1 are assumed to
22091 continue similar to current practices under the No Action Alternative, including actions at
22092 Klickitat Wildlife Area and Sondino Ponds in Washington for western pond turtle. It is assumed
22093 that wildlife concentrations and use of habitats in the lower Columbia River estuary would not
22094 change under MO1 from current conditions as described in the No Action Alternative.

22095 **FLOODPLAINS**

22096 Under MO1, changes in flood elevations would typically be negligible (absolute value less than
22097 0.3 foot) across the Columbia River Basin for all flood frequencies, from regularly occurring
22098 floods (AEP of 50 percent) to the base flood (AEP of 1 percent). Minor reductions in flood
22099 elevations (absolute value less than 1 foot) are predicted in Region D for the Columbia River
22100 below Bonneville Dam for floods with moderate to low frequencies (AEP values from 15 to 2
22101 percent). Based on these results, the annual average probability of inundation would remain
22102 unchanged from current conditions in most of the basin, with minor reductions in inundation
22103 frequency below Bonneville Dam. These changes could have minor effects on the floodplain in
22104 this reach.

22105 **SPECIAL STATUS SPECIES**

22106 Table 3-103 provides details about ESA-listed wildlife species that are known or likely to occur
22107 in the study area and potential effects to these species or their critical habitats in response to
22108 implementation of MO1. Similar to the No Action Alternative, it is assumed that federally listed
22109 species present in the study area would remain listed and existing regulatory and best
22110 management practices would reduce the likelihood that populations would continue declining
22111 or go extinct.

22112 None of the special status species, except Ute ladies'-tresses suitable habitat, would be
22113 impacted by MO1 beyond No Action Alternative conditions. At Grand Coulee, the variable
22114 hydrology would have an effect on Ute ladies'-tresses if a population is found in the study area.
22115 Therefore, there may be a negligible effect on Ute ladies'-tresses populations within or
22116 downstream of Grand Coulee.

22117 As described in Section 3.5, the fish models predict a small increase in smolt-to-adult returns,
22118 and overall abundances of adult salmon and steelhead would lead to a small increase in prey
22119 base available to marine mammals foraging in the Columbia River, such as seal or sea lion, or
22120 offshore from the mouth of the Columbia River, such as killer whale. In addition, increased spill
22121 in MO1 relative to the No Action Alternative is predicted to decrease the number of spring
22122 migrating juvenile salmon and steelhead transported to below Bonneville Dam, thereby
22123 increasing the number of juvenile fish available as prey in the between McNary Dam and
22124 Bonneville dam during the spring. This could increase the prey base available to colonial nesting
22125 waterbirds and other fish eating predators in this river reach (Table 3-106).

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22127 Table 3-103. Sensitive Species Effects for MO1

Common Name	Scientific Name	Status of Species and Critical Habitat	Projects Where Species Occurs	Effects of MO1
Mammals				
Grizzly bear	<i>Ursus arctos horribilis</i>	ESA status: T CH: Proposed	Libby Hungry Horse	Construction of structures on the dam: No effect. No structures are proposed under MO1. Bear are spatially removed from the dam projects. Hydrology: Negligible effect. Altering riparian vegetation to drier vegetation (i.e., conifers) at Libby Dam. No effects to the species at Hungry Horse study area. Conclusion: Negligible effect. Effects associated with MO1 are similar to the NAA. MO1 is not likely to adversely affect the grizzly bear.
Columbian white-tailed deer	<i>Odocoileus virginianus leucurus</i>	ESA status: T CH: None	Downstream of Bonneville	Construction of structures on the dam: Negligible effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Water surface elevation changes minimal (<1 foot) and within range of natural variation. Not likely to convert suitable habitat or flood individuals. Conclusion: Negligible effect. Effects associated with MO1 are similar to the NAA. MO1 is not likely to adversely affect the Columbia white-tailed deer.
California sea lion	<i>Zalophus californianus</i>	ESA status: None CH: None Marine Mammal Protection Act	Downstream of Bonneville, occasionally to The Dalles Dam	Construction of structures: Negligible effect: Temporary, minimal visual and noise disturbance, potentially resulting in avoidance of the area. Hydrology: Negligible effect. Water surface elevation changes minimal (<1 foot) and within range of natural variation. Prey availability: Negligible effect. Slight increase in prey availability. Conclusion: Negligible effects associated with MO1 are similar to the NAA. Hazing would continue similar to the NAA. Overall population of California sea lions would remain stable.
Steller sea lion	<i>Eumetopias jubatus</i>	ESA status: None CH: None Marine Mammal Protection Act	Downstream of Bonneville	Construction of structures on the dam: Negligible effect. Temporary, minimal visual and noise disturbance, potentially resulting in avoidance of the area. Hydrology: Negligible effect. Water surface elevation changes minimal (<1 foot) and within range of natural variation. Prey availability: Negligible effect. Slight increase in prey availability. Conclusion: Negligible effect. Effects associated with MO1 are similar to the NAA. Hazing would continue similar to NAA. Overall population of Steller sea lions would remain stable.
Southern Resident killer whale Distinct Population Segment	<i>Orcinus orca</i>	ESA Status: E CH: None	None	Construction of structures on the dam: No Effect. Disturbance would not extend to suitable habitat for Southern Resident killer whales, no individuals or habitat affected. Hydrology: Negligible effect. Water surface elevation changes minimal (<1 foot) and within range of natural variation. Prey Availability: Negligible effect. The Snake River spring/summer Chinook is a negligible portion of their overall diet. Fish models predict that lower Snake River Chinook salmon smolt-to-adult returns would slightly increase under MO1 Fish hatcheries would continue similar to the NAA. This overall effect could change Southern Resident killer whale distinct population segment behavior both over the short and long term as whales react to the changes in prey availability. Conclusion: Negligible effect. Effects associated with the MO1 are similar to the NAA. .MO1 is not likely to adversely affect the Southern Resident killer whale.
Birds				
Yellow-billed cuckoo	<i>Coccyzus americanus</i>	ESA status: T CH: Proposed	Study area is within the range of yellow-billed cuckoo.	Construction of Structures on the dam: No Effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Minor effect. Water fluctuations at Libby would result in high winter flows that prevent establishment of cottonwoods galleries. Within Regions B, C, and D, water surface elevation changes minimal (<1 foot) and within range of natural variation. Not likely to convert suitable habitat or flood individuals. Conclusion: Minor effect to habitat. Effects associated with MO1 are similar to the NAA. MO1 is not likely to adversely affect the yellow-billed cuckoo.
Bald eagle and golden eagle	<i>Haliaeetus leucocephalus</i> <i>Aquila chrysaetos</i>	ESA Status: none CH: none Bald and Golden Eagle Protection Act	Throughout the study area.	Construction of structures on the dam: Negligible effect. Hydrology: Negligible effect. The bald eagle nests in mature cottonwood trees. Cottonwood trees would continue to decline under MO1. Conclusion: Negligible effects associated with the MO1 are similar to the NAA. MO1 is not likely to adversely affect bald or golden eagle populations.

Common Name	Scientific Name	Status of Species and Critical Habitat	Projects Where Species Occurs	Effects of MO1
Streaked horned lark	<i>Eremophila alpestris strigata</i>	ESA status: T CH: Designated	Downstream of Bonneville	Construction of Structures on the Dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Water surface elevation changes minimal (<1 foot) and within range of natural variation. Not likely to convert suitable habitat or flood individuals. Conclusion: Negligible effect associated with the MO1 are similar to the NAA. MO1 is not likely to adversely affect the streaked horned lark.
Plants				
Ute ladies'-tresses	<i>Spiranthes diluvialis</i>	ESA status: T CH: None	Grand Coulee Chief Joseph	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Minor effect. Grand Coulee: Changes in water surface elevations would alter regions along the water margins where the plant could occur. Conclusion: Minor effect. Grand Coulee hydrology under MO1 would be more variable than the NAA and would have a negative effect on the plant, if the plant were to occur along the banks and margins of Lake Roosevelt. However, water surface elevations would be within existing operational limits. MO1 is not likely to adversely affect Ute ladies'-tresses.

22128 Note: C = Candidate for listing; CH = Designated Critical Habitat; E = Endangered; T = Threatened.

22129 **SUMMARY OF EFFECTS**

22130 Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue,
22131 including protection, mitigation, and enhancement of wildlife habitat as discussed in Section
22132 5.3.1.3. The effect of MO1 could be summarized by region as discussed in the following
22133 sections.

22134 In Region A, under MO1, changes to available wildlife habitat, wetlands, and vegetation would
22135 primarily occur in Lake Kooconusa and the Kootenai River. The average annual drop in surface
22136 water elevations between April and May in the Kootenai River would dry wetland types along
22137 the riverbanks and riparian areas, allowing for colonization of vegetation along the exposed
22138 shoreline. Later in the growing season, wetlands would flood. The effect would be a minor
22139 effect on wildlife usage. MO1 would provide additional stability to beaver colonies on the lower
22140 Kootenai River due to decreased variability in December flows. Ecosystem effects would trickle
22141 down, benefiting other wildlife. In Lake Kooconusa, the quantity of barren area around the lake
22142 would decrease under MO1, allowing for more potential vegetation establishment around the
22143 margins of the lake which would have a minor beneficial effect on wildlife that access the lake.

22144 Also in Region A, the marginal changes in water flows and elevations downstream of Hungry
22145 Horse Reservoir, along the South Fork Flathead River, and in the Albeni Falls area from
22146 implementing MO1 would not alter wetland habitats, vegetation communities, or wildlife
22147 populations compared to the No Action Alternative. Overall, for Region A, there would be a
22148 minor effect to wildlife, vegetation, and wetland resources associated with operation of Libby
22149 Dam under MO1 and a negligible effect for the other areas in Region A. The annual average
22150 probability of inundation would remain unchanged from current conditions, with negligible
22151 effects on floodplain benefits in Region A.

22152 In Region B, the largest effect under MO1 to vegetation, wildlife, and habitat would be
22153 associated with a large decrease in water surface elevation at Lake Roosevelt. The frequency
22154 and duration of drying conditions would increase for areas with emergent herbaceous and
22155 forested and scrub-shrub wetlands, and these habitats would transition into upland habitats, or
22156 plant communities in these habitats would transition to predominantly species more tolerant of
22157 dry conditions. This would change plant composition and distribution, or reduce the overall
22158 quantity of wetland acreage. These vegetation and habitat changes are expected to reduce
22159 overwintering habitats for wintering waterfowl and diving ducks, as well as wildlife populations
22160 supported by wetland habitats in the Grand Coulee Dam area. The size of the barren area
22161 during winter under lower water surface elevations would also increase under MO1 and would
22162 have an impact on wildlife species and revegetation in these margin areas. Overall, for Lake
22163 Roosevelt, there would minor effect on habitat, vegetation, and the corresponding wildlife
22164 under MO1. For the other areas in Region B, there would be a negligible effect to habitat,
22165 vegetation, and the corresponding wildlife. The annual average probability of inundation would
22166 remain unchanged from current conditions in Region B, with negligible effects on floodplain
22167 benefits.

22168 In Region C, the summer draft at Dworshak Reservoir would cause a drawdown that would
22169 cause a larger barren area and increased drying out of amphibian eggs. While the barren area
22170 around the reservoir would be larger, emergent vegetation would be established in some
22171 portions of the barren area to form seasonal herbaceous wetlands. Portions of the Clearwater
22172 River and island habitats downstream from Dworshak Dam would experience a marginal
22173 increase in inundation (1.5 inches) in June and July, associated with changes in water surface
22174 elevations following increased outflow from the *Modified Dworshak Summer Draft* measure.
22175 While this would be a minor change in inundation, it would represent a minor improvement in
22176 habitat for amphibians and birds. Because the lower Snake River Projects are run of the river,
22177 there would be a minor change to inundation and inflows. Overall, MO1 would have a minor
22178 (Dworshak) and minor (lower Snake River) change to vegetation, habitat, and wildlife in Region
22179 C. The annual average probability of inundation would remain unchanged from current
22180 conditions in Region C, with negligible effects on floodplain benefits.

22181 In Region D, water surface elevations are expected to largely decrease up to 6 inches during the
22182 spring and summer (February through September) within the mainstem of the Columbia River.
22183 These changes would be within the range of natural variability and daily fluctuations would be
22184 similar to the No Action Alternative. However, water levels in Lake Umatilla would increase by
22185 as much as 1.5 feet during the Caspian tern breeding season as a result of the *Predator*
22186 *Disruption Operation* measure. This action would inundate low-lying island habitats upstream of
22187 John Day Dam that provide habitat to colonial nesting waterbirds under the No Action
22188 Alternative. As a result, there would be less habitat available throughout Region D for colonial
22189 nesting waterbirds, such as Caspian terns and gull species. All other changes in river flow and
22190 water levels in Region D are expected to stay within the range of normal fluctuations and
22191 anticipated to remain the same as under the No Action Alternative. Overall, MO1 would have a
22192 negligible effect on vegetation, wetlands, habitat, and wildlife. Minor reductions in the annual
22193 average probability of inundation would occur below Bonneville Dam, with minor effects on
22194 floodplain benefits in this region.

22195 For special status species in all regions, none of the special status species, except Ute ladies'-
22196 tresses suitable habitat, would be impacted by MO1 beyond No Action Alternative conditions.
22197 At Grand Coulee in Region B, the variable hydrology could have an effect on Ute ladies'-tresses
22198 if the plant were located within the area of effect. Therefore, there may be an effect on Ute
22199 ladies'-tresses populations within or downstream of Grand Coulee from MO1. Overall, there
22200 would be a negligible to low impact on special status species.

22201 **3.6.3.4 Multiple Objective Alternative 2**

22202 Chapter 2, Alternatives, contains a description of how the CRS would be operated under MO2.
22203 A full description of the alternative can be found in Section 2.4.4.

22204 MO2 includes the *Ramping Rates for Safety* measure at all storage projects, the results of which
22205 would change the rate and magnitude of ramping operations to increase hydropower
22206 generation. It would also increase the operational range of the reservoirs to allow for increased
22207 flexibility to shape power production to meet demand. Implementing this measure would alter

22208 within-day timing, speed, frequency, duration, and magnitude of ramping and result in changes
22209 to water surface elevations in reservoirs and along downstream of all projects. Habitats
22210 affected by these changes would include shoreline and wetlands, the barren zone, and
22211 potentially near-shore aquatic habitats. The nature and magnitude of the effects would depend
22212 upon the parameters of specific operations for hydropower generation. Faster ramping rates of
22213 longer duration would generally be expected to produce more adverse effects than slower
22214 ramping rates or shorter duration. However, because the Ramping Rates for Safety measure
22215 would require that ramping rates do not compromise safety or soil stability in the reservoir or
22216 downstream of the projects, this measure would not increase erosion or bank sloughing in the
22217 study area compared to No Action Alternative conditions.

22218 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

22219 No structural measures would be implemented in Region A as part of MO2. Six operational
22220 measures would be implemented in Region A that differ from current operations as described
22221 under the No Action Alternative: the *Ramping Rates for Safety, Slightly Deeper Draft for*
22222 *Hydropower, Sliding Scale at Libby and Hungry Horse, Modified Draft at Libby, December Libby*
22223 *Target Elevation, and Winter System FRM Space* measures. Collectively, these measures alter
22224 draft and refill procedures to increase hydropower generation while balancing FRM, adjusting
22225 winter pool elevation targets, initiating a sliding scale to draft the pool at Libby and Hungry
22226 Horse, and lifting flow and reservoir elevation restrictions.

22227 Under MO2, water surface elevations in Lake Koocanusa would be lower for the majority of the
22228 year, specifically in the winter and early summer months, compared to the No Action
22229 Alternative. The *December Libby Target Elevation* measure would result in an end-of-November
22230 draft target that is 8 feet lower than the No Action Alternative. The MO2 target pool is 7 to 11
22231 feet lower than the No Action Alternative resulting in a deeper draft that continues until the
22232 end of February; many of the drier years do not recover the additional space drafted in
22233 December. Years with forecasts less than 6.9 Maf have deeper drafts due to the *Modified Draft*
22234 *at Libby* measure. Both the *Modified Draft at Libby* and the *December Libby Target Elevation*
22235 measures result in lower water surface elevations in Lake Koocanusa until June. August and
22236 September pool elevations would be approximately 0.5 foot higher than the No Action
22237 Alternative due to the *Sliding Scale at Libby and Hungry Horse* measures. The primary habitat
22238 type affected by these changes would be the barren zone, and emergent herbaceous and
22239 forested and scrub-shrub wetland habitats adjacent to the reservoir. In most years, deeper
22240 drafts would result in a wider barren zone. As a result, the reservoir pool elevation would be
22241 approximately 5 feet lower compared to the No Action Alternative, thereby increasing the area
22242 of exposed ground that could be colonized by non-native invasive plants.

22243 The primary habitat type affected by implementing the *December Libby Target Elevation*
22244 measure is the barren zone, which would increase by 11.5 feet and 10.3 feet of vertical
22245 elevation around the reservoir in December and January, respectively. The *Modified Draft at*
22246 *Libby* measure drafts the reservoir deeper, resulting in a wider barren zone compared to No
22247 Action Alternative conditions. A wider barren zone would provide an increased area of exposed

22248 ground where small mammals are more vulnerable to predation. Because flowering rush
22249 (*Butomus umbellatus*) is present in Flathead Lake in Montana and downstream in the Kootenai
22250 River in Idaho, newly exposed mudflats in Lake Kooconusa would provide suitable habitat for
22251 establishment of this species, which disperses quickly and degrades overall habitat quality. The
22252 relaxed ramping rates and reduced pool elevation restrictions from the *Ramping Rates for*
22253 *Safety and Slightly Deeper Draft for Hydropower* measures would cause increased fluctuations
22254 in pool elevations and outflow to maximize load shaping for hydropower generation. The
22255 effects of changing ramping rates would inundate or desiccate shoreline habitats. Fluctuating
22256 water levels also promote flowering rush establishment and population expansion (Hroudová et
22257 al. 1996).

22258 Lower water levels in Lake Kooconusa in December through May would reduce hydrologic
22259 connectivity of adjacent wetlands, which in turn would lead to decreased productivity in
22260 wetlands located at the mouths of tributaries, like the Tobacco River. Because water levels in
22261 Lake Kooconusa would drop upwards for 11.5 feet, wetland habitats would convert to upland
22262 habitats over time as habitat conditions shift from wetlands supporting willows and
22263 cottonwoods to drier conditions supporting more drought-tolerant plant species. As habitats
22264 shift, existing vegetation would decrease and cause a temporary increase in the rates of decay
22265 and lower dissolved oxygen (DO) levels. Changes in DO affect benthic invertebrates and residual
22266 effects to these communities impact the overall food web. Changes less than 0.5 foot would be
22267 difficult to measure and are assumed consistent with natural variation and fluctuations in water
22268 levels resulting from daily operations. Abrupt changes in pool elevations in Lake Kooconusa
22269 during the growing season could inundate and reduce available waterfowl habitat. Water levels
22270 in the reservoir would be 3.8 feet and 2.0 feet lower than the No Action Alternative in May and
22271 June, respectively, and trend towards a 0.7-foot rise from the No Action Alternative in
22272 September. Active nests attached to aquatic vegetation or connected to the shoreline, like
22273 those of western grebe (*Aechmophorus occidentalis*), American coot (*Fulica americana*), and
22274 cinnamon teal (*Spatula cyanoptera*), may become submerged or disconnected, resulting in
22275 decreased productivity or increased rates of predation.

22276 There are few islands in Lake Kooconusa under the No Action Alternative for nesting
22277 waterbirds; however, MO2 operations would support exposure of island habitats and
22278 development of nesting habitat in the spring and summer. Islands currently inundated under
22279 the No Action Alternative, like Cedar, Murray, Kins, and Whites Islands, would be exposed
22280 under MO2. Over time, these islands could become established with vegetation and develop
22281 into nesting habitat for waterbirds, including Clark's grebe (*Aechmophorus clarkii*); great blue
22282 heron (*Ardea herodias*) and black-crowned night heron (*Nycticorax nycticorax*); white-faced ibis
22283 (*Plegadis chihi*); Franklin's gull (*Leucophaeus pipixcan*); Caspian tern (*Hydroprogne caspia*),
22284 Forster's tern (*Sterna forsteri*), common tern (*S. hirundo*), and black tern (*Chlidonias niger*), all
22285 of which are considered species of concern in Montana (Wightman, Tilly, and Cilimburg 2011).
22286 Birds that nest early in the nesting season would be able to establish nests and rear young
22287 during this timeframe. However, as pool elevations increased in the late summer (July through
22288 September), any nests that were still active with eggs or juveniles and within 0.5 foot (vertical
22289 distance) of the pool elevation could become inundated, which could lead to nest failure.

22290 Measures in MO2 would cause notable changes in outflow from Libby in almost every season;
22291 however, changes would be most evident during winter as a result of the *December Libby*
22292 *Target Elevation* measure. Average monthly outflows would change from an approximately 30
22293 percent increase in the late summer, fall, and winter (i.e., June through September, November
22294 and December) to an approximately 10 to 40 percent decrease in the late winter and early
22295 spring (i.e., January, February, and March). Releases in April and May would be approximately 5
22296 to 25 percent lower to support aggressive refill according to the *Modified Draft at Libby*
22297 measure. In mid-May, outflow would increase in all but the driest years. Overall, these changes
22298 would decrease the spring freshet, which supports vegetation and wildlife in the Kootenai
22299 River.

22300 In the free-flowing reach of the Kootenai River between Libby and Bonners Ferry, water levels
22301 (compared to the No Action Alternative) could be up to several feet higher in the early winter
22302 and occasionally over a foot lower during the rest of the year. Minor changes are expected
22303 downstream of Bonners Ferry. As a result of higher winter flows, the banks of the Kootenai
22304 River would be inundated, and any riparian seeds and seedlings deposited during the summer
22305 months could be carried downstream as flows recede in January. Lower spring freshets would
22306 reduce the deposition of riparian seeds onto the riverbanks and lower the likelihood of
22307 cottonwood establishment and recovery of these forests. Higher winter flows and increased
22308 water levels would freeze the shorelines and increase the likelihood of bank sloughing and
22309 erosion in the winter months, leading to degraded water quality. Because these measures at
22310 Libby would result in higher winter flows and lower spring flows, the current trend of declining
22311 quantity and quality of deciduous plant communities and conversion to coniferous uplands
22312 would slightly accelerate under MO2 (KTOI 2013). Wildlife populations dependent upon
22313 forested and scrub-shrub wetland habitats would be reduced under MO2. The effect would be
22314 major, without mitigation, over the long term as these habitats could eventually be eliminated.
22315 Through the F&W Program, Bonneville has funded the KTOI to manage and implement large-
22316 scale habitat restoration measures within the Kootenai River. These habitat restoration actions
22317 have increased the active floodplain and work to restore riparian forest habitat, including
22318 efforts to restore black cottonwood galleries.

22319 Operational changes at Hungry Horse to maximize hydropower generation (Ramping Rates for
22320 Safety and Slightly Deeper Draft for Hydropower) would result in lower pool elevations during
22321 winter and spring months (i.e., January through June) compared to the No Action Alternative.
22322 The reservoir would be drafted in January and would be approximately 8 feet lower compared
22323 to No Action Alternative conditions through May in average years. In dry years, the reservoir
22324 would be drafted even more to maintain hydropower generation. There would be no change to
22325 late summer conditions on the reservoir. The full pool elevation would not change under MO2
22326 and this water surface elevation would be reached during the growing season in July. The
22327 primary habitat types affected by these changes would be the barren zone and emergent
22328 herbaceous and forested and scrub-shrub wetland habitats adjacent to the reservoir. In most
22329 years, deeper drafts would result in a wider barren zone. As a result, the barren zone would
22330 expand this area by approximately 5 vertical feet compared to the No Action Alternative,
22331 increasing the area of exposed ground that could be colonized by non-native invasive plants.

22332 Despite maintaining current wildlife habitats, wildlife surrounding both Libby and Hungry Horse
22333 Reservoir would experience an increased risk of predation when the reservoir is drawdown in
22334 the early part of the growing season due to increased exposure to predators, similar to other
22335 alternatives. The *Ramping Rates for Safety* measure and decreased water levels during the
22336 winter months (from the *Slightly Deeper Draft for Hydropower* measure to increase
22337 hydropower generation) could result in effects to riparian vegetation on the South Fork
22338 Flathead River downstream. These effects would likely be minor due to the confined and
22339 generally rocky nature of the South Fork River below the dam, and due to transmission
22340 limitations that already limit generation benefits that less restrictive ramping rate are intended
22341 to benefit.

22342 Downstream of Hungry Horse, water levels on the South Fork Flathead and mainstem Flathead
22343 Rivers would increase from operations to increase hydropower generation. These operations
22344 would raise water levels at Columbia Falls by approximately 1 to 1.5 feet in January. This
22345 increase in water levels would be followed by slightly lower water levels (less than 0.5 foot) in
22346 the early part of the growing season between March and June. For the remainder of the year,
22347 water levels at and downstream of Columbia Falls would be consistent with No Action
22348 Alternative conditions.

22349 As a result of higher winter flows, the banks of the Flathead River would be inundated, and any
22350 riparian seeds and seedlings deposited during the summer months would be carried
22351 downstream as flows recede in January. Lower spring freshets would reduce the deposition of
22352 riparian seeds onto the riverbanks and lower the likelihood of cottonwood establishment and
22353 recovery of these forests. Higher water levels in the channel would freeze shorelines that are
22354 above ordinary high water under the No Action Alternative, which would increase the likelihood
22355 of bank sloughing and erosion, leading to degraded water quality. Because these measures at
22356 Hungry Horse would result in higher winter flows and lower spring flows, there could be a shift
22357 to vegetation communities more tolerant of dry conditions under MO2. Wildlife populations
22358 dependent upon forested and scrub-shrub wetland habitats could be reduced under MO2.

22359 Operational changes at Hungry Horse would influence the Pend Oreille Basin, but with
22360 increasingly diluted effects closer to Albeni Falls as tributary inputs provide inflow to the river.
22361 The operational changes at Hungry Horse would increase Lake Pend Oreille water levels during
22362 the winter and spring by approximately 0.5 foot and decrease water levels by approximately 0.5
22363 foot between March and May.

22364 Implementing the *Ramping Rates for Safety* measure at Hungry Horse would influence flow
22365 conditions and water surface elevations at Albeni Falls. However, changes resulting from
22366 implementation of this measure would result in negligible effects on the quantity, quality, or
22367 distribution of wildlife habitats or populations in the Albeni Falls study area. The discussion
22368 below focuses on the potential effects of implementing MO2 operations at Albeni Falls.

22369 Habitats most likely to be affected by the fluctuating water levels would be mudflats and barren
22370 zones, emergent herbaceous and forested and scrub-shrub wetlands, submerged aquatic beds,
22371 and islands. Implementing MO2 would increase the repeated exposure of mudflats and barren

22372 lands compared to the No Action Alternative, exposing these areas to increased rates of erosion
22373 from boat wakes, wind, and waves. Wildlife species most likely to be affected include
22374 waterfowl, shorebirds, beaver, muskrats, amphibians, and insects.

22375 Under MO2, changing ramping rates and draft conditions at Albeni Falls would change water
22376 surface elevations on Lake Pend Oreille and the Pend Oreille River downstream of the dam.
22377 These changes would result in increased desiccation of submerged aquatic vegetation and
22378 emergent wetland plants, which could lead to decreased productivity and changes to plant
22379 composition in wetland habitats over time. These changes would be paralleled by wildlife
22380 dependent on wetland habitats, including amphibians and insects. Similarly, the quantity,
22381 quality, and distribution of wetland vegetation would change if ramping rates result in lower
22382 water elevations. Under these conditions, emergent herbaceous and forested and scrub-shrub
22383 wetland vegetation occurring adjacent to the shoreline would be disconnected hydrologically
22384 from the river under MO2. Decreasing hydrologic connectivity of wetland habitats would lead
22385 to an overall reduction in productivity and a shift in the composition of plant species to those
22386 more tolerant of dry or drought conditions. Downstream of the dam changes in ramping could
22387 alter patterns of seed dispersal, germination, and establishment, and the long-term viability of
22388 emergent herbaceous and forested and shrub-scrub wetlands along the shoreline.

22389 The shifting water levels on the Pend Oreille River would impact a variety of aquatic and
22390 terrestrial wildlife immediately downstream of Albeni Falls Dam, such as beaver and muskrats,
22391 amphibians, and waterfowl. If beaver lodges or other mammal dens are temporarily isolated
22392 from the shoreline as water levels drop relative to No Action Alternative conditions, these
22393 locations would be unsuitable for wildlife. Changes in water surface elevations on Lake Pend
22394 Oreille, particularly in Denton Slough during the nesting season, would alter the availability of
22395 vegetation and suitable nesting habitat for western grebe. If water levels drop rapidly or lower
22396 than No Action Alternative conditions, nests could dislodge, tip, and break apart, which would
22397 result in mortality of eggs or young. Rapid ramping rates would expose nests to increased risk
22398 of predation and failure, especially if nests are dislodged and pulled out of the slough where
22399 they would be exposed to recreational boat traffic and weather.

22400 Under MO2, a reduction in water levels from ramping rates and a deeper drawdown would
22401 decrease the quality of off-channel habitat for wildlife by increasing the distance between
22402 suitable nesting habitat and the water. Reducing the quantity and quality of off-channel habitat
22403 available in sloughs and bays would force waterfowl, amphibians, and reptiles like turtles to
22404 relocate to areas closer to the main reservoir where the risk of exposure to boats, high winds,
22405 and waves is greater (Hull 2019). While migratory birds would be adversely affected by
22406 reduction in the quantity and quality of wetland habitats from altered patterns of exposure and
22407 inundation, shorebirds would benefit from increased quantity of foraging habitat on exposed
22408 mudflats during the spring and summer breeding season.

22409 The operational changes at Region A from MO2 would also be evident in downstream reaches
22410 of the Columbia River, as discussed in the Regions B and D sections below. In regard to
22411 potential effects in Canada, the effects to vegetation and wildlife resources and their habitats

22412 under MO2 are expected to be similar to the effects described for the United States portion of
22413 Region A.

22414 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

22415 No structural measures would be implemented in Region B as part of MO2. Six operational
22416 measures would be implemented in Region B, which differ from current operations as
22417 described under the No Action Alternative: the *Ramping Rates for Safety, Slightly Deeper Draft*
22418 *for Hydropower, Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Grand*
22419 *Coulee Maintenance Operations, and Winter System FRM Space* measures. Collectively, these
22420 measures increase operational flexibility to maximize hydropower generation by altering draft
22421 and refill procedures while balancing FRM, and allowing for slightly deeper and earlier drafts
22422 during larger forecast years.

22423 Overall, Lake Roosevelt would have lower winter water levels compared to the No Action
22424 Alternative during drawdown due to the change in draft rates associated with the *Planned Draft*
22425 *Rate at Grand Coulee* and *Slightly Deeper Draft for Hydropower* measures. Implementing MO2
22426 would result in deeper drafts for hydropower, which would decrease water surface elevations
22427 in Lake Roosevelt by approximately 3 to 6 feet during the winter months. Because the measures
22428 would be implemented during the winter months, there would be negligible changes to
22429 habitats during the growing season, and as a result, there would be no change to the quantity,
22430 quality, and distribution of wildlife habitat in the study area.

22431 Similar to MO1, changes to water surface elevations or fluctuating water conditions in Lake
22432 Roosevelt could impact the quantity and quality of foraging habitat for wintering waterfowl.
22433 Decreasing pool elevations would decrease the quantity and suitability of open water habitat
22434 and decrease access to emergent or submerged aquatic vegetation in shallow-water areas for
22435 loon and other waterfowl foraging on the reservoir. Unlike MO1, lower lake levels would not
22436 persist into the growing season and effects to waterfowl would be limited to winter forage
22437 habitat. By spring, water surface elevations in Lake Roosevelt would be consistent with No
22438 Action Alternative conditions.

22439 Lower winter lake elevations would impact predator-prey relationships along the shoreline of
22440 the reservoir and on portions of the lake itself. Because water levels would be lower, bighorn
22441 sheep populations, specifically, would be adversely affected as a result of increased exposure to
22442 predation from mountain lion (Wood 2019). Conversely, deer and other ungulates would
22443 benefit from lower reservoir elevations and corresponding decrease in wolf predations.

22444 Any changes in water levels at the upstream ends of Chief Joseph Reservoir and the other
22445 projects through the middle Columbia reach (Wells Dam, Priest Rapids, etc.) would occur as a
22446 result of the changes in outflow from Grand Coulee associated with the *Ramping Rates for*
22447 *Safety* measure. Flow conditions and water levels would generally increase in December as a
22448 result of the *Winter System FRM Space* measure and decrease between February and
22449 September. Both the increase in winter water levels and the decrease in spring and summer
22450 would be less than 0.5 foot compared to No Action Alternative conditions and these changes

22451 would be most evident in the free-flowing Hanford Reach downstream of Priest Rapids Dam.
22452 Changes less than 0.5 foot would be difficult to measure and are assumed to be consistent with
22453 natural variation and fluctuations in water levels resulting from daily operations. Changes in the
22454 annual average probability of inundation from current conditions would be negligible.
22455 Therefore, this measure would have no effect on the quantity, quality, or distribution of wildlife
22456 habitats or populations in Grand Coulee study area and would have negligible effects on
22457 floodplain function.

22458 The effects of implementing operational changes at Grand Coulee under MO2 would be evident
22459 throughout the lower Columbia River, as discussed below for Region D. Specifically, the *Planned*
22460 *Draft Rate at Grand Coulee* and *Winter System FRM Space* measures would influence water
22461 levels upriver of McNary Dam (i.e., the Hanford Reach). In regard to potential effects in Canada,
22462 the effects to vegetation and wildlife resources and their habitats under MO2 are expected to
22463 be similar to the effects described for the United States portion of Region B.

22464 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
22465 **HARBOR DAMS**

22466 The following structural measures would be implemented as part of MO2 in Region C: the
22467 *Additional Powerhouse Surface Passage, Fewer Fish Screens, Upgrade to Adjustable Spillway*
22468 *Weirs, Lower Snake Ladder Pumps, Turbine Strainer Lamprey Exclusion, Bypass Screen*
22469 *Modifications for Lamprey, and Lamprey Passage Ladder Modifications* measures. Collectively,
22470 these measures increase downstream survival of juvenile salmon, steelhead, and lamprey, and
22471 improve upstream passage conditions for adult salmon, steelhead, and lamprey. These
22472 structural measures are limited to the immediate vicinity of the project dams on the lower
22473 Snake River and construction-related effects would not result in widespread effects to wildlife
22474 habitats or populations in the Region C study area.

22475 The following operational measures would be implemented as part of MO2 in Region C: the
22476 *Spill to 110 percent TDG, Ramping Rates for Safety, Full Range Reservoir Operations, Slightly*
22477 *Deeper Draft for Hydropower, Full Range Turbine Operations, Increase Juvenile Fish*
22478 *Transportation, Contingency Reserves During Fish Passage Spill, Winter System FRM Space, and*
22479 *Zero Generation Operations* measures. Collectively, these measures would increase the
22480 generation of affordable, non-fossil fuel energy sources through increased hydropower
22481 production and increased integration of non-hydropower renewable power sources such as
22482 wind and solar; increase flexibility to raise and lower flows and increase the ability for
22483 hydropower to meet fluctuations in demand; increase juvenile fish transportation; alter draft
22484 and refill procedures to increase hydropower generation while balancing FRM; allow more
22485 water to pass through the turbines and thereby reduce the incidence of high TDG levels; and
22486 adjust winter pool elevation targets.

22487 Dworshak Dam would be drafted for hydropower generation, and reservoir elevations would
22488 decrease by approximately 2.5 to 30 feet January through April, decrease by approximately 10
22489 feet in May and June, and recover to essentially the same elevation as the No Action
22490 Alternative by the end of July. Despite the magnitude of change compared to the No Action

22491 Alternative, implementing MO2 in the Dworshak study area would be consistent with the
22492 effects analysis described above for Albeni Falls in Region A. Implementing the measures
22493 associated with MO2 would result in changes to water levels, impacting barren zones and
22494 mudflats, emergent herbaceous and forested and scrub-shrub wetlands, and submerged
22495 aquatic beds. Fluctuations in pool elevations would decrease hydrologic connectivity to
22496 floodplains and emergent herbaceous and forested and scrub-shrub wetlands, which would
22497 lead to desiccation of plants or a shift in plant composition to species more tolerant of dry or
22498 drought conditions.

22499 Wildlife affected by these changes would include waterfowl, shorebirds, amphibians, and
22500 insects. In response to changing foraging conditions in emergent herbaceous wetlands and
22501 shallow- and open-water habitats, waterfowl and shorebirds would relocate to areas with
22502 suitable foraging habitat.

22503 In addition, as a result of the *Slightly Deeper Draft for Hydropower* measure, water levels in the
22504 Clearwater River would be approximately 1 foot higher in January when compared to the No
22505 Action Alternative. Minor increases in the annual average probability of inundation would
22506 occur, with minor effects on floodplain benefits. The more exposed shoreline conditions during
22507 the growing season would dry wetland habitats.

22508 On the Clearwater River, changes in water levels resulting from the *Ramping Rates for Safety*
22509 measure would desiccate emergent herbaceous and forested and scrub-shrub wetland
22510 habitats. Longer prolonged drying from the *Slightly Deeper Draft for Hydropower* measure
22511 would encourage the plant species composition in these habitats to transition to species more
22512 tolerant of dry or drought conditions and a portion of wetland habitats may transition to upland
22513 habitat. Downstream of Dworshak, changes in outflows associated with hydropower generation
22514 would alter the patterns of seed dispersal, germination, and establishment of forested and
22515 scrub-shrub wetland plants like willows or cottonwoods. Depending on the level of change, this
22516 measure could impact the long-term viability of wetland habitats along the shorelines of the
22517 Clearwater River.

22518 Under MO2, the reservoir elevations at the four lower Snake River dams would differ from
22519 those of the No Action Alternative due to the full *Range Reservoir Operations* measure, which
22520 calls for operating within the full reservoir operating range throughout the year, instead of
22521 reducing the normal operating range in the MOP season, April through August. Lower Granite
22522 Dam and Little Goose Dam reservoir would increase approximately 4.0 feet higher during high
22523 water events in April through August compared to the No Action Alternative. Lower
22524 Monumental Dam and Ice Harbor reservoir would operate approximately 2 foot higher than the
22525 No Action Alternative.

22526 This measure would therefore increase the quantity, quality, and distribution of wetland
22527 habitats in the Lower Snake River. Emergent herbaceous wetland may become established in
22528 new areas where the water depth and inundation patterns support establishment of wetland
22529 vegetation and soil conditions. Scrub-shrub and forested wetlands adjacent to the shoreline
22530 may convert to emergent because of this prolonged inundation. This effect would be minor.

22531 There would be a conversion in the quality and distribution of existing emergent herbaceous
22532 and forested and scrub-shrub wetlands under MO2 when compared to the No action
22533 Alternative. Existing wetlands would continue to be productive habitats, supporting breeding
22534 amphibians, reptiles, mammals, and birds during spring and summer breeding season. As a
22535 result, there would be some effects to wildlife populations using these habitats. For example,
22536 the overall quantity and quality of habitat for ground-nesting birds, such as the harlequin duck
22537 that breed along well-concealed streambanks or on islands between Silcott Island and Ice
22538 Harbor, would increase. Additionally, if some woody vegetation transitions to emergent
22539 vegetation over time, the amount of nesting habitat for birds such as veery or warblers that
22540 nest in wetland thickets may decrease. In these circumstances, birds may be forced to relocate
22541 to other areas where suitable nesting habitat is available, which could increase competition for
22542 limited resources. As a result, the overall distribution in quantity of invasive species in Region C
22543 would remain similar to the No Action Alternative. Where no management efforts are
22544 implemented, invasive species are expected to persist under MO1 similar to the No Action
22545 Alternative.

22546 Similar to the fish transport measures included in MO1 and MO4, the *Increase Juvenile Fish*
22547 *Transportation* measure would decrease the quantity of juvenile salmon and steelhead
22548 available to avian and mammalian predators in the lower Snake River between April 25 and
22549 August 31. Decreasing the number of juveniles in the lower Snake River study area would
22550 decrease overall prey resources supporting a variety of wildlife populations at higher trophic
22551 levels (e.g., colonial nesting waterbirds, waterfowl, and otter). Wildlife populations in the lower
22552 Snake River that are dependent on juvenile salmonids as a prey source would transition to
22553 other resources, or populations may relocate to other areas where prey resources are more
22554 widely available. However, the results of the fish modeling analysis in Section 3.5 indicate fish
22555 would move through the system more slowly and survival for juvenile salmon and steelhead
22556 that migrate in-river would be lower than under the No Action Alternative.

22557 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

22558 Structural measures associated with MO2 in Region D would include the *Lamprey Passage*
22559 *Structures, Turbine Strainer Lamprey Exclusion, and Lamprey Passage Ladder Modifications*
22560 measures. These measures would collectively increase downstream survival of juvenile lamprey
22561 and improve upstream passage conditions for adult lamprey. These structural measures would
22562 be limited to the immediate vicinity of the project dams on the lower Columbia River and
22563 construction-related effects would not result in widespread effects to wildlife habitats or
22564 populations.

22565 Under MO2, there would be no change to the reservoir elevations at McNary, The Dalles, Dam,
22566 or Bonneville Dam. At John Day Dam, the *John Day Full Pool* measure calls for operating the
22567 reservoir in a range that goes up to 266.5 feet NGVD29 year round, except as needed for FRM.
22568 When operation is needed for FRM, the full operating range (257.0 to 268.0 feet NGVD29) may
22569 be used, as is the case for the No Action Alternative. Pool elevations would be between 1.5 foot
22570 higher than the No Action Alternative from March 15 to April 9 and increase by 2.5 feet higher

22571 than the No Action Alternative from April 10 to September 30. Consequently, floodplains,
22572 aquatic, or terrestrial habitats and wildlife populations in the John Day study area would be
22573 moderately impacted by the changes of implementing MO2.

22574 Operational measures associated with MO2 in Region D also include the *Ramping Rates for*
22575 *Safety, John Day Full Pool*, and *Increase Juvenile Fish Transportation* measures. Collectively,
22576 these measures would influence operations in Region D and decrease downstream survival of
22577 juvenile salmon and steelhead, entering the estuary, decreasing the survival and return of adult
22578 salmon and steelhead, and increasing flexibility for hydropower generation.

22579 Changes to water surface elevations and the average probability of inundation in the McNary,
22580 The Dalles, and Bonneville Dam study areas would be negligible and within the natural range of
22581 variability, so minor impacts to floodplains are expected (see additional information below). As
22582 a result, the quantity, quality, and distribution of habitat would be moderately wetter than No
22583 Action Alternative conditions. Burbank Slough and McNary NWR would not experience changes
22584 in water levels or flow conditions, and habitats would remain consistent with No Action
22585 Alternative conditions.

22586 As a result, the quantity, quality, and distribution of habitat would not change measurably from No
22587 Action Alternative conditions and there would be no corresponding changes to wildlife populations.
22588 Existing wetlands would continue to be productive habitats, supporting breeding amphibians, reptiles,
22589 mammals, and birds during the spring and summer breeding season. These wetland habitats would
22590 continue to support regionally important migratory waterfowl overwintering in the Umatilla NWR IBA by
22591 providing forage opportunities and prey resources.

22592 Minor reductions in flood elevations would occur below Bonneville Dam for floods that occur
22593 with moderate to low frequency, which could have minor effects on floodplain benefits in this
22594 region. On average, changes in river levels downstream of Bonneville Dam would be within the
22595 natural range of variability in daily water levels. For this reason, MO2 is not expected to cause
22596 measurable effects to wildlife populations or their habitats downstream of Bonneville Dam. The
22597 lower portions of the Columbia River would continue to support valuable habitat for fish and
22598 wildlife, and current trends are expected to continue.

22599 Similar to the juvenile fish transport measures included in MO1 and MO4, the *Increase Juvenile*
22600 *Fish Transportation* measure included in MO2 and detailed in the Region C section above would
22601 decrease the quantity of juvenile salmon and steelhead available to avian and mammalian
22602 predators between the lower Snake River and Bonneville Dam between April 25 and August 31.
22603 Decreasing the number of juveniles in the John Day, The Dalles, and Bonneville Dam study areas
22604 would decrease overall prey resources supporting a variety of wildlife populations at higher
22605 trophic levels, specifically colonial nesting terns, gulls, and pelicans in Lake Wallula and Lake
22606 Umatilla. These colonies prey heavily on juvenile salmonids and fewer fish would likely force
22607 birds to transition to other prey resources or relocate breeding activities to other areas on the
22608 Columbia Plateau where prey resources are more widely available. Depending on the
22609 availability of nesting habitat, this has the potential of causing a decline in predatory avian bird
22610 populations or shifting the predation problem elsewhere in the Columbia Plateau.

22611 **FLOODPLAINS**

22612 Under MO2, changes in flood elevations would typically be negligible (absolute value less than
22613 0.3 foot) across the Columbia River Basin for all flood frequencies, from regularly occurring
22614 floods (AEP of 50 percent) to the base flood (AEP of 1 percent). Minor reductions in flood
22615 elevations (absolute value less than 1 foot) are predicted in Region D for the Columbia River
22616 below Bonneville Dam for floods with moderate to low frequencies (AEP values from 15 to 2
22617 percent). Based on these results, the annual average probability of inundation would remain
22618 unchanged from current conditions in most of the basin, with minor reductions in inundation
22619 frequency below Bonneville Dam. These changes could have minor effects on floodplain
22620 benefits in this region.

22621 **SPECIAL STATUS SPECIES**

22622 Table 3-104 provides details about ESA-listed wildlife species that are known or likely to occur
22623 in the study area and potential effects to these species or their critical habitats in response to
22624 implementation of MO2. Similar to the No Action Alternative, it is assumed that federally listed
22625 species present in the study area would remain listed and existing regulatory and best
22626 management practices would reduce the likelihood that populations would continue declining
22627 or go extinct. It is assumed that neither grizzly bear critical habitat nor whitebark pine would be
22628 listed and their presence and population in, or in the vicinity of, the study area would remain
22629 relatively stable.

22630 As described in Section 3.5, the fish models predict differing levels of SARs under MO2 in
22631 comparison to the No Action Alternative. The CSS model predicts a reduction in SARs, while the
22632 LCM predicts a small increase due to the increase in the number of fish that will be transported
22633 under the *Spill to 110 Percent TDG* and the *Increase Juvenile Fish Transportation* measures.
22634 Under the CSS model predictions these changes in the overall abundance of adult salmon and
22635 steelhead would decrease the prey base available to marine mammals foraging in the Columbia
22636 River, such as seal or sea lion, or offshore from the mouth of the Columbia River, such as killer
22637 whale. Under the LCM model predictions, the small increase in SARs would increase the prey
22638 base to marine mammals foraging in the Columbia River or offshore from the mouth of the
22639 Columbia River. However, under either the CSS or LCM models, the overall effect would be
22640 negligible to these species.

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Table 3-104. Sensitive Species Effects for MO2

Common Name	Scientific Name	Status of Species and Critical Habitat	Projects Where Species Occurs	Effects of MO2
Mammals				
Grizzly bear	<i>Ursus arctos horribilis</i>	ESA status: T CH: proposed	Libby Hungry Horse	Construction of structures on the dam: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Water surface elevation would be lower by approximately 1.3 feet in May at Libby Dam and less than 1 foot at Hungry Horse Dam. This hydrology change at Libby Dam could alter riparian vegetation to vegetation types more tolerant of dry conditions, such as conifers in low lying areas. The effect at Libby reservoir is a slight drying of vegetation. At Hungry Horse, effects would be negligible. Conclusion: Negligible effect to grizzly bear from MO2. The grizzly bear is a generalist that relies on food sources throughout its home range. MO2 is not likely to adversely affect the grizzly bear.
Columbian white-tailed deer	<i>Odocoileus virginianus leucurus</i>	ESA status: T CH: None	Downstream of Bonneville	Construction of structures on the dam: No effect. No structures proposed and disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Water surface elevation changes minimal (<0.5 foot) and within range of natural variation. Not likely to convert suitable habitat or flood individuals. Conclusion: Negligible effect to Columbian white-tailed deer from MO2. MO2 is not likely to adversely affect the Columbian white-tailed deer.
California sea lion	<i>Zalophus californianus</i>	ESA status: None CH: None Marine Mammal Protection Act	Downstream of Bonneville Dam, occasionally to The Dalles Dam	Construction of structures on the dam: Negligible effect. Temporary impact, minimal visual and noise disturbance, potentially resulting in avoidance of the area. Prey availability: Negligible effect. Prey availability would be slightly less. Conclusion: Negligible effect. Hazing would continue similar to the NAA. Overall population of California sea lions would remain stable.
Steller sea lion	<i>Eumetopias jubatus</i>	ESA status: None CH: None Marine Mammal Protection Act	Downstream of Bonneville Dam	Construction of structures on the dam: Negligible Effect. Temporary impact, minimal visual and noise disturbance, potentially resulting in avoidance of the area. Prey availability: Negligible effect. Prey would be slightly less. Hazing would continue similar to NAA. Conclusion: Negligible Effect. Negligible effects associated with MO2 are similar to the NAA. Hazing would continue similar to the NAA. Overall population of Steller sea lions would remain stable.
Southern Resident killer whale Distinct Population Segment	<i>Orcinus orca</i>	ESA status: E CH: None	None	Construction of structures on the dam: No effect. Disturbance would not extend to suitable habitat for Southern Resident killer whale, no individuals or habitat affected. Prey Availability: Negligible effect. The Snake River spring/summer Chinook is a negligible portion of their overall diet. Fish models predict that lower Snake River Chinook salmon smolt-to-adult returns would be slightly less than NAA. Fish hatcheries would continue similar to NAA. This overall effect could change Southern Resident killer whale distinct population segment behavior, as whales react to the changes in prey availability. Conclusion: Negligible effect. Less available prey availability could change whale behavior to search for other available food sources or migrate to areas where food is more readily available. MO2 is not likely to adversely affect the Southern Resident killer whale distinct population segment.
Birds				
Yellow-billed cuckoo	<i>Coccyzus americanus</i>	ESA status: T CH: Proposed	Study area is within the range of yellow-billed cuckoo.	Construction of structures on the dam: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect to suitable habitat. Water fluctuations at Libby would result in high winter flows that could prevent establishment of cottonwoods galleries. Within Regions C and D, the water-surface elevation changes minimal (<1 foot) and within range of natural variation. Not likely to convert suitable habitat or flood individuals. Conclusion: Negligible effect. MO2 operations would continue trends of reduced riparian habitat suitable for yellow-billed cuckoo at Libby. Efforts to restore black cottonwood galleries within floodplains and along river corridors are being implemented within the upper basin by the Kootenai Tribe of Idaho, (KTOI) the Kalispel Tribe, and the Idaho Department of Fish & Game (IDFG) through Bonneville's F&W Program. No effect from operations under MO2 for Region C and D projects. MO2 is not likely to adversely affect the yellow-billed cuckoo.
Streaked horned lark	<i>Eremophila alpestris strigata</i>	ESA status: T CH: Designated	Downstream of Bonneville	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Water surface elevation changes minimal (<0.5 foot) and within range of natural variation. Not likely to convert suitable habitat or flood individuals. Conclusion: Negligible effect from operations under MO2. MO2 is not likely to adversely affect the streaked horned lark.

Common Name	Scientific Name	Status of Species and Critical Habitat	Projects Where Species Occurs	Effects of MO2
Bald eagle and golden eagle	<i>Haliaeetus leucocephalus</i> <i>Aquila chrysaetos</i>	ESA status: none CH: none Bald and Golden Eagle Protection Act	Throughout the study area.	Construction of structures on the dam: Negligible effect. Hydrology: Negligible effect. MO2 operations would reverse trends in reducing riparian habitat along the Kootenai River. Bald eagle would nest in mature cottonwood trees. Conclusion: Negligible effect. Efforts to restore black cottonwood galleries within floodplains and along river corridors are being implemented within the upper basin by the KTOI the Kalispel Tribe, and the IDFG through Bonneville's F&W Program. Therefore, the effect to bald and golden eagles should be negligible compared to the NAA. MO2 is not likely to adversely affect the bald or golden eagle.
Plants				
Ute ladies'-tresses	<i>Spiranthes diluvialis</i>	ESA status: T CH: None	Grand Coulee/Chief Joseph	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Grand Coulee: Changes in water surface elevations would alter regions along the water margins where the plant occurs. These fluctuations in water surface elevations are within normal operating pool. Conclusion: Negligible effect. Grand Coulee hydrology under MO2 would be more variable than the NAA and would have a negative effect on the plant, if the plant were to occur along the banks and margins of Lake Roosevelt. However, changes in hydrology are within normal operating pool. MO2 is not likely to adversely affect the Ute ladies'-tresses.

22644 Note: C = Candidate for listing; CH = Designated Critical Habitat; E = Endangered; T = Threatened.

22645 **SUMMARY OF EFFECTS**

22646 Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue,
22647 including protection, mitigation, and enhancement of wildlife habitat as discussed in Section
22648 5.2.1. The effect of MO2 could be summarized by region as follows:

22649 In Region A, the Lake Koocanusa barren zone would expand by approximately 5 feet compared
22650 to the No Action Alternative, increasing the area of exposed ground that could be colonized by
22651 native or non-native invasive plants. A wider barren zone would provide an increased area of
22652 barren zone where small mammals would be more vulnerable to predation and where
22653 flowering rush may establish. Measures in MO2 would cause notable changes in outflow from
22654 Libby Dam in almost every season, resulting in a decrease in the spring freshet, which supports
22655 vegetation and wildlife in the Kootenai River. Because these measures at Libby would result in
22656 higher winter flows and lower spring flows, there could be a decline in the quantity and quality
22657 of deciduous plant communities and conversion to coniferous uplands under MO2 compared to
22658 the No Action Alternative. Wildlife populations dependent upon forested and scrub-shrub
22659 wetland habitats could also be reduced under MO2. MO2 operations would support exposure
22660 of island habitats and development of associated nesting habitat in the spring and summer in
22661 these areas. Deeper Hungry Horse barren zones would alter wetland habitat types and result in
22662 increased barren areas. The higher winter flows and lower spring flows could result in a shift in
22663 downstream vegetation communities and associated wildlife communities. The areas in the
22664 Pend Oreille River near Albeni Falls Dam would experience a similar shift in vegetation, wildlife
22665 habitat, and wildlife communities. Additionally, the annual average probability of inundation
22666 would remain unchanged from current conditions in Region A, resulting in minor effects on
22667 floodplain benefits in this region. Overall, the effects from MO2 on vegetation and wetlands
22668 would be moderate, while effects to wildlife could be major.

22669 In Region B, decreasing pool elevations would decrease the quantity and suitability of open
22670 water habitat and decrease access to emergent or submerged aquatic vegetation in shallow-
22671 water areas for loon and other waterfowl foraging on the reservoir resulting in minor effects to
22672 waterfowl. These lower lake levels would not persist into the vegetation growing season and
22673 would have negligible impact on plant communities. Lower pool elevation in winter could result
22674 in potentially higher predation on wildlife species such as bighorn sheep. This would be a minor
22675 adverse effect for prey, such as ungulates. The quantity, quality, or distribution of wildlife
22676 habitats and populations for areas in Region B outside of the Lake Roosevelt area would not
22677 change from the No Action Alternative. Annual average probability of inundation would remain
22678 unchanged from current conditions in Region B. Overall, MO2 would have a minor effect to
22679 vegetation, wetlands, habitat, and wildlife in Lake Roosevelt. MO2 would have a negligible
22680 effect on these resources in the other locations in Region B.

22681 In Region C, changes in Dworshak reservoir water levels and river levels downstream of
22682 Dworshak would increase the timing and extent of the barren zones and mudflats, emergent
22683 herbaceous and forested and scrub-shrub wetlands, and submerged aquatic beds. Decreased
22684 hydrologic connectivity to emergent herbaceous and forested and scrub-shrub wetlands would

22685 lead to drying out of plants or a shift in plant composition to species more tolerant of dry or
22686 drought conditions. Changes in outflows associated with hydropower generation would alter
22687 the patterns of seed dispersal, germination, and establishment of forested and scrub-shrub
22688 wetland plants like willows or cottonwoods. Implementing MO2 would not result in measurable
22689 changes to water levels on the lower Snake River, and as a result, there would be no change to
22690 floodplain function or quantity, quality, or distribution of wildlife habitats in the lower Snake
22691 River study area. Increases in salmon transport in the area may result in increased prey base for
22692 wildlife. Overall, the effects from MO2 on vegetation, wetlands, wildlife, and habitat in Region C
22693 would be negligible.

22694 In Region D, the quantity, quality, and distribution of habitat would not change measurably
22695 from No Action Alternative and there would be no corresponding changes to wildlife
22696 populations. A reduction in the wetland habitats immediately downstream of Bonneville Dam
22697 could reduce wetland quantities and adversely impact the pond turtle, further threatening the
22698 viability of the regional population, but there would be little effect past Bonneville Dam in the
22699 lower Columbia River. Changes in prey base may result in wildlife and birds switching to other
22700 prey sources or relocating to alternate locations, which would result in minor impacts to these
22701 populations. Additionally, minor reductions in inundation frequency would occur below
22702 Bonneville Dam, resulting in minor effects on floodplain benefits in this region. Overall, the
22703 effects from MO2 on vegetation, wetlands, wildlife, and habitat in Region D would be
22704 negligible.

22705 For special status species in all regions, multiple special status species would be impacted by
22706 MO2 beyond No Action Alternative conditions. Overall, there would be a negligible impact on
22707 most special status species.

22708 **3.6.3.5 Multiple Objective Alternative 3**

22709 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

22710 No structural measures would be implemented in Region A under MO3 and, therefore, the
22711 proposed structural measures would not impact wetlands or wildlife habitats or populations.

22712 Under MO3, operational measures influencing Region A are the *Ramping Rates for Safety*,
22713 *Sliding Scale at Libby and Hungry Horse*, *Modified Draft at Libby*, *December Libby Target*
22714 *Elevation*, and *Hungry Horse Additional Water Supply* measures. Collectively, these measures
22715 would influence operations in Region A by altering ramping rates, as well as draft and refill
22716 procedures at Libby and Hungry Horse Dams, and modifying winter draft targets and summer
22717 drafting (similar to measures proposed under MO1). Operations would change as a result of
22718 implementing the *Ramping Rates for Safety* measure. In comparison with the No Action
22719 Alternative, implementing the *Ramping Rates for Safety* would permit greater flexibility in flows
22720 to allow water to be shaped (within-day) for hydropower production to meet demand. The
22721 *Hungry Horse Additional Water Supply* measure would reduce flows and have a minor influence
22722 (decrease) on WSE at Lake Pend Oreille and downstream of Albeni Dam.

22723 Under MO3, water surface elevations on Lake Koochanusa would be decreased in winter and
22724 spring, and increased in late summer, compared to the No Action Alternative. November and
22725 December reservoir elevations would be 7 to 11 feet lower in most years due to implementing
22726 the *December Libby Target Elevation* measure. The *Modified Draft at Libby* measure would
22727 implement a deeper draft in dry years, resulting in pool elevations that would be as much as 25
22728 feet lower from December through April when compared to the No Action Alternative.
22729 Reservoir elevations would increase by approximately 0.5 foot in the late summer from
22730 implementing the *Sliding Scale at Libby and Hungry Horse* measure.

22731 The primary habitat type affected by these changes is the barren zone, and emergent
22732 herbaceous and forested and scrub-shrub wetland habitats adjacent to the reservoir. In most
22733 years, deeper drafts would result in a wider barren zone. As a result, the barren zone would
22734 expand this area by approximately 5 feet compared to the No Action Alternative, increasing the
22735 area of exposed ground that would be colonized by native or non-native, invasive plants.

22736 The *Ramping Rates for Safety* measure has the potential to change the timing, speed or rate,
22737 and frequency of hydropower generation within a given day in Region A. Because hydropower
22738 generation influences pool elevations and river conditions downstream of project dams, it is
22739 anticipated that changing ramping rates for hydropower generation would result in effects to
22740 vegetation and wildlife. While the hourly or daily operational changes cannot be detected in
22741 modeling conducted for this analysis, it is assumed that an increase in fluctuations throughout
22742 the year could influence the quantity, quality or condition, and distribution of shoreline
22743 habitats. Changing water levels and altering patterns of inundation and seasonal drying have
22744 the potential to drown out vegetation, which would influence growth and establishment of
22745 plant communities and wildlife habitats.

22746 Lower water levels in the spring and early summer would reduce productivity in existing
22747 emergent herbaceous and forested and scrub-shrub wetlands where they occur at the mouths
22748 of tributaries, like the Tobacco River. If habitats become disconnected from water sources or
22749 current patterns of inundation change, plant growth and survival would decline, which would
22750 further result in unproductive or non-functioning habitats (DeBerry and Perry 2019).
22751 Furthermore, because pool elevations would be lower for the majority of the growing season,
22752 wetland habitats could transition into upland habitats or plant communities. For example, tree
22753 and shrub species like willows (*Salix* spp.) and cottonwoods (*Poplar* spp.) would dry out and the
22754 type of trees and shrubs would shift to species more tolerant of dry or drought conditions. A
22755 widespread dieback of emergent vegetation would lead to a temporary increase in vegetative
22756 decay and a subsequent decrease in dissolved oxygen, which would affect benthic invertebrates
22757 and the overall food web. If changes to pool elevations were abrupt, it would impact the quality
22758 and quantity of nesting habitat for waterfowl in the spring and summer. As water levels rise in
22759 summer by 0.5 to 5 feet from No Action Alternative, waterfowl nests attached to aquatic
22760 vegetation or connected to the shoreline may be submerged, and affect waterfowl like western
22761 grebe (*Aechmophorus occidentalis*), mallard (*Anas platyrhynchos*), American coot (*Fulica*
22762 *americana*), northern shoveler (*Spatula clypeata*), and cinnamon teal (*Spatula cyanoptera*).

22763 There are few islands in Lake Koochanusa under the No Action Alternative for nesting
22764 waterbirds; however, MO3 operations would support exposure of island habitats and
22765 development of nesting habitat in the spring and summer, similar to MO2.

22766 H&H modeling results indicate outflows would increase in the early winter (November and
22767 December) by approximately 10 to 35 percent and decrease for the remainder of the year by 5
22768 to 40 percent under MO3. As a result, water levels on the Kootenai River would be 0.5 to 2 feet
22769 higher in the early winter and 0.5 to 3 feet lower the rest of the year compared to No Action
22770 Alternative conditions. These changes would be most evident in the river from Libby Dam
22771 downstream to near Bonners Ferry, and would become less measurable below Bonners Ferry as
22772 water levels are largely controlled by Kootenai Lake elevations in Canada.

22773 As a result of these changes in outflow and subsequent water levels on the Kootenai River,
22774 implementing MO3 would increase water levels near Bonners Ferry, Idaho, in the winter. As
22775 discussed above, high winter flows would inundate riverbanks and redistribute seeds from
22776 forested wetland vegetation. Higher water levels in the winter would increase bank sloughing
22777 and erosion, potentially degrading water quality for aquatic wildlife. Furthermore, lower spring
22778 flows would reduce moisture content of soils, which would reduce the suitability of shoreline
22779 habitat in the spring and summer for seed deposition and plant establishment. Consequently,
22780 existing trends of diminishing deciduous tree cover, specifically cottonwood galleries and poor
22781 recruitment of saplings, would continue and would increase from No Action Alternative
22782 conditions (KTOI 2013). Large black cottonwood (*Populus trichocarpa*) trees along the banks of
22783 the Kootenai River respond to additional inundation in the winter or an increase in dry
22784 conditions in the spring, causing flood or drought response within a forest stand, which can
22785 impact health and growth of the forest stand. Through the F&W Program, Bonneville has
22786 funded the KTOI to manage and implement large-scale habitat restoration measures within the
22787 Kootenai River. These habitat restoration actions have increased active floodplain and work to
22788 restore riparian forest habitat, including efforts to restore black cottonwood galleries.

22789 Potential changes to water levels would influence management areas and refuge habitats, like
22790 the Kootenai Falls Wildlife Management Area near RM 202. Changing water levels have the
22791 potential to inundate and dry out narrow bands of emergent vegetation along the shoreline of
22792 management areas. These changes would have little effects to upland species, like mule deer,
22793 bighorn sheep, and white-tailed deer, but would alter the quantity and quality of wetland
22794 habitat types that are receiving flows from the Kootenai River (KTOI 2013).

22795 Because water levels would be approximately 0.5 to 2 feet lower in the spring and summer
22796 months, streamside thickets and wetland habitats could transition to plant communities more
22797 tolerant of dry or drought conditions. These changes would reduce nesting habitat for migrant
22798 songbirds, including veery (*Catharus fuscescens*), yellow warbler (*Setophaga petechia*), and
22799 common yellowthroat (*Geothlypis trichas*). Localized declines in forest health would reduce the
22800 availability of nesting habitat for raptors and waterbirds, which nest in forested wetlands during
22801 the breeding season. For example, if younger trees do not replace mature trees, nesting habitat
22802 for nesting bald eagles and great blue heron rookeries would decline.

22803 Lower spring and summer river conditions on the Kootenai River would dry off-channel sloughs
22804 and backwater habitats from May to late June, desiccating immotile amphibian eggs like those
22805 of the western toad (*Anaxyrus boreas*). If egg masses are desiccated and toads are unable to
22806 successfully breed in subsequent years, the effects of changing river conditions would lead to
22807 interruptions in the life cycle of this species. The northern leopard frog (*Lithobates pipiens*)
22808 would also decline if backwater habitats dry earlier in the season. The loss of thin-stemmed
22809 emergent vegetation would reduce the availability of egg-laying habitat required by the species.

22810 Aquatic invertebrates, like caddisflies and stoneflies, would experience minor interruptions in
22811 life cycle, which would disrupt food availability throughout the ecosystem. These
22812 macrobenthics would desiccate during times of drawdown and with more frequency and
22813 duration than under the No Action Alternative. Perching birds and bats dependent upon
22814 springtime emergence of aquatic insects would experience declines in reproductive success if
22815 invertebrate prey resources were not available in sufficient quantity to support breeding
22816 individuals. Bats common in the Kootenai River basin, like little brown bat (*Myotis lucifugus*)
22817 and Yuma myotis (*M. yumanensis*), may have difficulty feeding after emergence from winter
22818 torpor.

22819 At Hungry Horse Dam, the effects to vegetation, wetlands, and wildlife in the vicinity of the
22820 reservoir and along the South Fork Flathead and Flathead Rivers downstream of the dam,
22821 would be the same as those described under MO1, with the exception of the relaxation of
22822 ramping rates (*Ramping Rates for Safety*). This measure would increase and decrease flows in
22823 the South Fork Flathead River based on hydropower demand, rapidly inundating or exposing
22824 the streambank. This would not impact vegetation as flows would be within the operational
22825 range for the South Fork Flathead and mainstem Flathead Rivers and would be at or below high
22826 flows, which occur in the spring and early summer. A decrease of a few hundred cubic feet per
22827 second in spring represents a fraction of high flows and would be negligible. The banks along
22828 the South Fork Flathead River are well armored and vegetated, and any rapid change in flow
22829 would not alter vegetation along the reach. There would not be an effect in the Flathead River
22830 as any change in flow would be negligible and diluted by the North Flathead and Middle Fork
22831 Flathead flows. See Section 3.6.3.3 for greater details on potential effects in the Hungry Horse
22832 study area.

22833 Under MO3, implementation of the *Hungry Horse Additional Water Supply* measure would
22834 reduce flows on the Flathead, Clark Fork, and Pend Oreille Rivers in the winter and spring, and
22835 would have negligible effect on water surface elevations in Lake Pend Oreille and downstream
22836 of Albeni Falls Dam in order to provide the additional 90 kaf of water for use in the region
22837 above Flathead Lake. The effects of this measure and the resulting changes in flow would be
22838 water levels typically a few inches lower in the winter and spring in transitional and free flowing
22839 reaches. Despite these changes, the *Hungry Horse Additional Water Supply* measure would not
22840 influence the quantity, quality, or distribution of aquatic or wetland vegetation adjacent to the
22841 reservoir or river. As a result, the *Hungry Horse Additional Water Supply* measure would not
22842 influence wildlife habitats or populations in Albeni Falls study area.

22843 Similar to the discussion about the potential effects from changing ramping rates at Libby Dam,
22844 implementing MO3 at Albeni Falls Dam would result in potential effects to floodplains,
22845 vegetation, and wildlife. Water surface elevations and river conditions influence patterns of
22846 seed dispersal, plant establishment, vigor, and growth. Changing the pattern, timing or
22847 frequency of inundation as a result of increasing flexibility with ramping rates under MO3,
22848 would affect habitat quality and succession in the Albeni Falls study area. As a result, these
22849 changes would influence the quantity, quality, and distribution of aquatic and terrestrial
22850 habitats, and the suitability of these habitats for wildlife (Bejarano, Jansson, and Nilsson 2017),
22851 to an unknown degree.

22852 Changing ramping rates would affect mudflats, emergent wetlands, and marshes. These
22853 habitats would dry out more frequently and for longer durations compared to the No Action
22854 Alternative. As a result, invertebrate and amphibian populations would be the most vulnerable
22855 to this measure (International Finance Corporation, World Bank Group 2018). If water surface
22856 elevations decrease quickly, aquatic macroinvertebrates could be stranded on exposed
22857 sediments resulting in desiccation or predation. As a result, changing the patterns of inundation
22858 in these areas would influence the availability and quality of invertebrate populations to
22859 support foraging shorebirds and other waterbirds. Downstream of the dam, changes in ramping
22860 rates would alter flow conditions that support seed dispersal, germination, and establishment
22861 of emergent and woody vegetation, which could result in long-term changes to the viability of
22862 herbaceous, shrub-scrub, and forested wetlands along the shoreline. Faster ramping rates
22863 along with hourly or daily operational changes would generally be expected to produce more
22864 adverse effects than slower ramping rates, and less volatility in flow volume.

22865 As a result of potential effects to wetland habitats, changes in water surface elevations and
22866 river conditions could cause beaver and muskrat to locate dens and lodges to new or different
22867 locations compared to where they currently occur under the No Action Alternative. Similarly,
22868 changes in water surface elevations during the breeding season would impact the western
22869 grebe colony nesting in the Pend Oreille WMA, particularly in Denton Slough. Increases to
22870 ramping rates in the breeding season could destabilize floating nests and cause them to break
22871 apart or become unstable. As a result, grebes would experience increased rates of egg loss and
22872 juvenile mortality, decreasing overall reproductive success. Furthermore, changes to the
22873 frequency of wetting and drying cycles in wetland habitats in Denton Slough would affect the
22874 availability and quality of the plant material used for nest construction. If pool conditions
22875 change rapidly, grebe and other waterfowl nests would be pulled from protected portions of
22876 the slough into the main reservoir where they would experience increased exposure to
22877 motorized boat traffic, predators, and extreme weather (Hull 2019). As a result, grebes and
22878 other waterfowl would experience higher rates of nest failure compared to the No Action
22879 Alternative.

22880 In regard to potential effects in Canada, the effects to vegetation and wildlife resources and
22881 their habitats under MO3 are expected to be similar to the effects described for the United
22882 States portion of Region A

22883 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

22884 At Grand Coulee Dam, MO3 comprises five operational measures in the study area: *Ramping*
22885 *Rates for Safety, Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Grand*
22886 *Coulee Maintenance Operations, and Lake Roosevelt Additional Water Supply*. These measures
22887 are intended to limit ramping rates for safety purposes only; reduce the risk of landslides
22888 around Lake Roosevelt in the winter and spring; provide operational constraints to maintain
22889 hydraulic capacity; increase reservoir capacity to protect against rain-induced flooding in
22890 Portland, Oregon, and Vancouver, Washington; and support water diversions for irrigation and
22891 withdrawals for municipal and industrial uses. Collectively, these measures minimally influence
22892 water surface elevations in Lake Roosevelt and downstream reaches of the Columbia River, as
22893 well as outflow from Grand Coulee Dam.

22894 Implementing the operational actions under MO3 would have a range of effects in Grand
22895 Coulee Dam study area; however, there are only minimal changes to water levels on an average
22896 water year as a result of those operational changes, thus negligible effects to floodplains would
22897 be expected. Diverting water for irrigation results in minimal changes in water surface
22898 elevations immediately upstream of the dam in Lake Roosevelt (approximately 0.5-foot
22899 increase during the winter months, and less than 1.0-foot decrease during the spring months).
22900 These changes are more similar to No Action Alternative conditions than either the MO1 or
22901 MO4 alternatives. A decrease of 1.0 foot in water surface elevations during the growing season
22902 (April to October) would affect emergent herbaceous wetland habitat. However, the water
22903 surface elevation returns to conditions consistent with the No Action Alternative by May and
22904 this change is not anticipated to result in changes to habitat conditions in Lake Roosevelt under
22905 MO3, and as a result, no effects to local wildlife are expected to occur under MO3.
22906 Consequently, these measures have little to no effect on the quantity, quality, and distribution
22907 of habitats in the study area and, therefore, low potential for negative effects to wildlife
22908 populations in the study area.

22909 In regard to potential effects in Canada, the effects to vegetation and wildlife resources and
22910 their habitats under MO3 are expected to be similar to the effects described for the United
22911 States portion of Region B

22912 At Chief Joseph Dam, MO3 includes the *Chief Joseph Dam Project Additional Water Supply*
22913 measure, which diverts water from the Columbia River during the growing season (April
22914 through October) to support irrigation on authorized lands downstream from the dam.
22915 However, despite the loss of this water from the river system, there is less than a 1 percent
22916 change in water surface elevations to the river immediately downstream of Chief Joseph Dam,
22917 and changes are less measurable further downstream. As a result, the *Chief Joseph Dam Project*
22918 *Additional Water Supply* measure is not expected to result in measurable effects to floodplains,
22919 habitats, or wildlife populations upstream of Chief Joseph Dam. Changes downstream of Chief
22920 Joseph Dam are negligible and would not affect habitats or wildlife populations under MO3.

22921 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
22922 **HARBOR DAMS**

22923 Structural measures associated with MO3 in Region C include *Breach Snake Embankments* and
22924 *Lower Snake Infrastructure Drawdown*. These measures breach the four dams on the lower
22925 Snake River. These structural measures are intended to increase downstream survival of
22926 juvenile salmon and steelhead, and improve upstream passage conditions for adult salmon,
22927 steelhead, and lamprey. In addition, these structural measures would result in widespread
22928 effects to floodplains, wildlife habitats, and populations. Partial breaching of the dam
22929 infrastructure would not affect the timing or volume of river flows (although water particle
22930 travel time would be faster) but would eliminate the reservoir environment. The *Lower Snake*
22931 *Infrastructure Drawdown* measure would provide additional equipment to minimize adverse
22932 effects of TDG during drawdown procedures.

22933 Three operational measures are associated with MO3: *Drawdown Operating Procedures*,
22934 *Drawdown Contingency Plans*, and *Ramping Rates for Safety*. Because the dams would be
22935 removed from the system, operations for Ice Harbor, Lower Monumental, Little Goose, and
22936 Lower Granite Dams would occur only during activities associated with breaching to facilitate
22937 the safe and efficient drawdown of the reservoirs, and then operations would cease at these
22938 projects. Operations at Dworshak Dam would continue to discharge flows on the Clearwater
22939 River, partially influencing flows in the lower Snake River. See Section 3.2 and 3.3, *Hydrology*
22940 *and Hydraulics*, for greater detail on changes to sediment transport and hydrology. Ramping
22941 rate limitations would be defined only for the purpose of safety or geotechnical concerns such
22942 as erosion. The purpose is to increase flexibility in flows to allow water to be shaped for
22943 hydropower production to meet power demand.

22944 Increasing ramping rates at Dworshak Dam would cause vegetation to become dislodged and
22945 create unvegetated islands/shoreline environments. In addition, ramping rates can strand fish,
22946 macroinvertebrates, and other organisms within the barren zone. These events can cause
22947 desiccation of amphibian eggs or dislodgement of ground-nesting birds.

22948 For the lower Snake River projects, construction activities associated with breaching the dams
22949 and specific effects to existing habitats and wildlife would be detailed in a future NEPA
22950 document, but the analysis below provides an overview of expected changes to Region C under
22951 MO3. Breaching the lower Snake River dams would decrease average surface water elevations,
22952 resulting in both short- and long-term effects to floodplains, habitats, and wildlife populations
22953 in Region C. Although changes to habitats and plant communities, and corresponding changes
22954 to wildlife populations, would shift over time, the duration of short-term effects from habitat
22955 loss and the time needed for habitats to transition from one type to another are uncertain.

22956 The analysis below summarizes effects to habitat and wildlife in two time periods: short-term
22957 and long-term effects. These time periods are not mutually exclusive, nor do they represent the
22958 same span of time for every habitat type or species group. Rather, these time frames
22959 contextualize the effects and are a tool to evaluate trends over time. In general, short-term
22960 effects to plant communities would occur within 10 years of dam breaching; long-term effects

22961 or changes would occur after a minimum of 60 years. Wildlife populations respond to changes
22962 in habitat more quickly, and, as a result, short-term effects to wildlife would occur within 5
22963 years of dam breaching and long-term effects to wildlife would occur after 5 years.

22964 Short-term construction activities associated with breaching of earthen embankments at each
22965 dam and the subsequent construction of diversion dams (such as stockpiling and haul road
22966 construction) would have adverse effects on upland habitats and associated wildlife for the
22967 duration of construction. These effects include, but are not limited to, ground disturbance, soil
22968 compaction, removal of vegetation, surface hardening, noise, and human presence.
22969 Construction activities include construction of haul roads, equipment storage, and stockpile and
22970 staging areas. As described in Chapter 2, breaching the four dams would occur over a space of 4
22971 years, 2 years to breach Lower Granite and Little Goose Dams, and 2 years to breach Lower
22972 Monumental and Ice Harbor Dams. Adverse effects from construction activities would be
22973 minimized by implementing BMPs.

22974 Water surface elevations would drop approximately 95 to 110 feet in some places and
22975 approximately 13,800 acres of bare substrate (mostly sand and silt) would be exposed along the
22976 banks of the river following deconstruction. Approximately 3,000 acres of habitat management
22977 units that are currently irrigated under the No Action Alternative would no longer be irrigated,
22978 and these lands would transition to upland plant communities. Therefore, the quantity and
22979 distribution of shrub-steppe and grassland habitats would increase under MO3. Approximately
22980 12,440 acres would be expected to transition from lands currently inundated under the No
22981 Action Alternative to upland habitats under MO3.

22982 Until vegetation establishes along the shorelines, which may take 5 to 15 years, erosional
22983 processes and accretion would continue to modify and shape the riverbanks. Immediately after
22984 breaching the dams in the lower Snake River, approximately 350 acres of emergent herbaceous
22985 and forested and scrub-shrub wetland habitats in embayments, off-channel sloughs, and other
22986 still-water and fringe areas around the reservoirs would be lost as water levels drop, and these
22987 habitats would transition to upland plant communities. Plant species in these habitats that
22988 would be sensitive to the drawdown include shallow rooting plants such as willows (*Salix* spp.),
22989 false indigo bush (*Amorpha fruticosa*), and white alder (*Alnus rhombifolia*). Wetland vegetation
22990 along tributary streams, seeps, and springs would be retained after dam breach, as these
22991 habitats would be supported by groundwater from tributary systems. Additionally, well-
22992 established forested and scrub-shrub wetlands that are currently dominated by drought-
22993 tolerant plant species may be retained in areas nearer to the mouth of the Snake River.

22994 Because most emergent herbaceous and forested and scrub-shrub wetlands are linked to
22995 hydrologic regimes associated with the Snake River, changing conditions from a reservoir
22996 system to lower elevation riverine system would cause major effects on the occurrence of
22997 floodplains, and would impact long-term habitat quantity, quality, and distribution throughout
22998 the 140-mile section of river. Approximately 1,900 acres of wetland habitats would be lost.
22999 These habitats would transition quickly to upland habitats. Over the next 15 to 60 years,
23000 approximately 1,500 acres of new wetland habitats would develop along the riverbanks.

23001 As the river stabilizes after breaching, a variety of plant communities and habitats would
23002 develop along the shorelines. The structure and function of these habitats would be guided by
23003 biological, physical, and hydrologic conditions and various management decisions by state,
23004 Federal, and tribal entities. The types and species of plants that would colonize the exposed
23005 shorelines would be dictated by the distribution of seed stocks within the substrate, the
23006 presence of wind and water-borne seeds, and hydrologic conditions. Robberecht (1998) found
23007 that there is a sufficient seed bank in the shallow areas of the reservoirs (i.e., less than 15 feet
23008 water depth) to allow for rapid colonization of exposed banks. Below that depth, the viability
23009 and abundance of seeds diminishes, and active restoration is needed to support desired plant
23010 communities. For dam breaching of this extent, native vegetation would not establish without
23011 mitigation efforts that include planting and seeding as well as invasive species management.

23012 Robberecht's findings also suggest that newly established plant communities within the upper
23013 15 feet of the barren zone would be composed predominantly of native herbaceous species;
23014 however, a substantial amount of non-native seeds were also identified in the substrates. Due
23015 to the presence of non-native seeds and the potential for wind and water dispersal, it is
23016 possible that non-native plant communities would dominate the majority of the exposed lands
23017 following drawdown. Some of the more widespread non-native species identified by
23018 Robberecht (1998) include prickly lettuce (*Lactuca serrola*), puncture vine (*Tribulus terrestris*),
23019 curly dock (*Rumex crispus*), common yellow sweetclover (*Melilotus officinalis*), water-cress
23020 (*Nasturtium officinale*), Russian thistle (*Salsola soda*), and bull thistle (*Cirsium vulgare*). Existing
23021 stands of non-native purple loosestrife, flowering rush, and reed canary grass would decline
23022 after dam breaching because these species are associated with wetland habitats; however, the
23023 newly exposed shorelines would provide habitat for these and other non-native species to
23024 establish as habitats stabilize over time. The success of native plant communities would be
23025 determined by several factors, including the degree of floodplain connectivity and the
23026 frequency and duration of inundation, and land management actions, including implementation
23027 of invasive species control.

23028 Prior to construction of the dams, the lower Snake River contained a mosaic of approximately
23029 3,285 acres of emergent herbaceous and forested and scrub-shrub wetlands (Corps 1975,
23030 1991). Historical aerial imagery of the lower Snake River indicates approximately 1,500 acres of
23031 forested and scrub-shrub habitats could develop after dam breaching. These habitats would
23032 provide breeding and foraging habitat for a wide variety of wetland and upland species.
23033 Compared to No Action Alternative conditions, deep sediment deposits adjacent to the post-
23034 breaching river corridor would be more conducive to the establishment of wetland habitats
23035 than the rocky, shallow soils immediately adjacent to existing shorelines. Similarly, the wider,
23036 flatter shorelines of the post-breach river corridor would also support wetland habitat
23037 establishment and development compared to the steep side-slopes of current conditions. Over
23038 time, natural processes of erosion, accretion, and nutrient transport could support the
23039 development of high-quality wetlands distributed throughout the lower Snake River.

23040 Under MO3, the existing reservoirs would be drawn down and habitat conditions would change
23041 in the study area as described above. The resulting draw down would result in a substantial

23042 change to the character of vegetation and water quality along the Snake River between its
 23043 confluence with the Clearwater River and its mouth where it flows into the Columbia River.
 23044 These changes would include the loss of approximately 1,200 acres of woody vegetation along
 23045 the existing shorelines of the reservoirs, increased risk of invasive species establishment, and
 23046 degraded water quality from high suspended sediments and turbidity from sediment
 23047 movement, erosion, and bank sloughing (Table 3-105). These changes in habitat and water
 23048 quality would result in short- and long-term effects to wildlife, both adverse and beneficial.
 23049 Animals which are dependent on wetland habitats, such as amphibians, would be impacted by
 23050 widespread losses of these habitats during and immediately after dam breaching; individuals
 23051 would die if adjacent wetland habitats were inaccessible. Conversely, some wildlife would
 23052 experience temporary benefits from breaching the dams, such as shorebirds that would benefit
 23053 from an expansion of foraging habitat when mudflats are exposed during and after dam
 23054 breaching.

23055 **Table 3-105. Estimated Short-term Habitat Losses and Long-term Habitat Gains in the Study**
 23056 **Area Under Multiple Objective Alternative 3**

Habitat Type	Short-Term Losses ^{1/} (acres)	Long-Term Gains ^{2/} (acres)
Upland		
Agriculture, Pasture, and Mixed Environments	462.50	5,601.40
Eastside (Interior Grasslands)	0.00	3,852.30
Shrub-steppe	0.00	2,342.60
Exposed Rock and Rock Talus	0.00	642.90
Total Upland Habitat	462.50	12,439.20
Wetland		
Palustrine Forested/Scrub-shrub	1,188.90	1,481.20
Palustrine Emergent	353.20	0.00
Palustrine Open Water (ponds)	315.70	0.00
Total Wetland Habitat	1,857.80	1,481.20
Reservoir/River^{3/}	13,772.00	0.00
Total Project Lands	2,320.30	13,920.40

23057 1/ These are gross numbers. They do not factor in potential mitigation through maintenance of irrigation in habitat
 23058 management units or continued development in Corps Managed Lands.

23059 2/ Long-term gains are based on the assumption that habitats will return to their pre-project distribution. It does
 23060 not assume that habitat management units or Corps Managed Lands will be maintained. Exact distribution of
 23061 habitat types following drawdown is not quantifiable.

23062 3/ Not included in the total.

23063 Source: HEP Analyses 1995; Corps 2002

23064 Wildlife can easily access water from the reservoirs under the No Action Alternative. Because
 23065 the dam breach would create a wide barren zone between the river channel and vegetated
 23066 upland habitats, access to water would be limited to wildlife who can safely traverse the barren
 23067 zone, or access tributary streams, springs, and seeps. Individuals traversing the barren zone,
 23068 such as gallinaceous birds like chukar and quail or small mammals, would experience increased
 23069 risk of predation while foraging or accessing water at the river's edge. For several years after

23070 dam breaching, natural cover for roosting, feeding, escaping, or nesting along the
23071 approximately 13,800 acres of exposed shorelines, mudflats, and islands would be limited or
23072 non-existent.

23073 Implementing MO3 could have varying effects on upland mammals such as elk, bighorn sheep,
23074 black bear, and mountain lion. These species occur in very low numbers in the lower Snake
23075 River Canyon and are not highly associated with wetland habitats. Large mammals that are
23076 associated with forested wetland habitats, such as mule and white-tailed deer, would be
23077 temporarily adversely impacted by a reduction in suitable foraging habitat and protective cover
23078 during and immediately following dam breaching as existing wetland habitats transition to
23079 upland grassland or shrub-steppe habitats. As wetland and woody vegetation establishes along
23080 the river channel, more contiguous habitat conditions would increase the quantity of area over
23081 the long term by providing protective cover for migrating and transient upland mammals.

23082 Winter conditions for mule and white-tailed deer would improve compared to No Action
23083 Alternative conditions as brush and woody vegetation becomes established in the river
23084 corridor. In 1984, the then Washington Department of Game and USFWS estimated that the
23085 amount of prime wintering habitat lost following inundation of the lower Snake River was
23086 capable of supporting 1,200 deer. Breaching the dams would result in a loss of approximately
23087 1,200 acres of forested wetland habitat; however, it is anticipated that approximately 1,500
23088 acres of emergent herbaceous and forested and scrub-shrub wetland habitats would develop
23089 along the new river channel. Furthermore, as vegetation becomes established on the exposed
23090 shorelines, these areas would provide additional foraging habitat for deer. Islands formed after
23091 drawdown would provide fawning habitat for deer if islands were inaccessible to mammalian
23092 predators. Currently, only New York Island at RM 78 provides suitable cover for fawning.
23093 Following implementation of MO3, newly exposed islands would provide refuge and suitable
23094 protective cover for deer during fawning.

23095 Mammals such as coyote and bobcat would experience short-term benefits from increased
23096 availability of prey resources such as waterbirds, invertebrates, and small mammals that are
23097 exposed after dam breach from a lack of cover. The widespread loss of approximately 670 acres
23098 of wetland habitats would reduce the availability of emergent herbaceous and forested and
23099 scrub-shrub wetlands for shelter and breeding habitat until these habitats become established
23100 along the banks of the new river channel. Aquatic mammals, such as otter, beaver, raccoon,
23101 and muskrat would experience loss of breeding, foraging, and sheltering habitat and degraded
23102 water quality during and immediately after dam breaching. High turbidity would adversely
23103 impact foraging success until suspended sediments settle out of the water column and increase
23104 visibility (see Section 3.4, *Water Quality*).

23105 Under the No Action Alternative, reservoir conditions support abundant otter populations
23106 because substantial denning habitat is available on the reservoir shorelines. Dam breaching and
23107 reservoir drawdown would decrease the number of denning sites and isolate existing dens from
23108 the river. As a result, the overall population of otters may temporarily decline following
23109 implementation of MO3 because denning habitat would be limited and the availability of fish

23110 resources in the years following dam breaching would support fewer individual otters. Muskrat
23111 and beaver are closely associated with emergent riparian habitats, which would be lost during
23112 and immediately following dam breaching. Breeding and foraging habitat for these species
23113 would be limited until vegetation and wetland habitats are reestablished several years after
23114 dam breaching and individuals may experience increased predation. However, individuals
23115 would return to the system when food resources and shelter develops in forested and shrub-
23116 scrub wetlands. Over time, populations of terrestrial and aquatic mammals would recover and
23117 stabilize as habitats transition and become established along the river corridor.

23118 Small mammals would experience increased predation and habitat loss under MO3. Rocklage
23119 and Ratti (1998) found more individuals and overall diversity of small mammal species in
23120 wetland sites than upland or grassland habitats in the lower Snake River study area. Loss of
23121 wetland sites would increase exposure of small mammals to predators as habitats transition to
23122 upland habitat types. However, the risk of predation would diminish over time as populations
23123 become established in wetland habitats after they develop along the new river channel. If
23124 wetland habitats are more contiguous along the new river channel compared to the No Action
23125 Alternative, long-term population numbers for small mammals may increase where suitable
23126 habitat exists and covers more area. It is estimated that approximately 1,500 acres would
23127 develop into emergent herbaceous and forested and scrub-shrub wetlands adjacent to the river
23128 channel compared to approximately 1,200 acres that exist under No Action Alternative. Small
23129 mammal species associated with upland grassland or shrub-steppe habitats, such as Ord's
23130 kangaroo rat (*Dipodomys ordii*) or bushy-tailed woodrat (*Neotoma cinerea*), would benefit from
23131 the transition of habitats because the availability and distribution of upland habitat would
23132 increase by approximately 12,500 acres following dam breaching and reservoir drawdown.

23133 Bats in the study area would be adversely impacted by a reduction in invertebrate and insect
23134 prey resources following dam breaching. Reducing the surface area of reservoirs would result in
23135 a loss of breeding habitat for invertebrate species. Many embayments and off-channel habitats
23136 would be exposed and isolated from the river channel following dam breaching and drawdown.
23137 These areas support insect reproduction and overall productivity of the food web. Species most
23138 likely to be affected by a reduction in insects following a reduction of wetland and ponded
23139 habitats include Townsend's big-eared bat and the Yuma myotis. Furthermore, as existing
23140 wetland habitats transition to upland habitats, roosting habitats for bats would decline until
23141 woody vegetation becomes established adjacent to the river corridor in future years.
23142 Approximately 650 acres of rocky habitat would be exposed from reservoir drawdown. These
23143 habitats provide roosting or hibernacula habitat for Western pipstrelle bats (*Pipistrellus*
23144 *hesperus*).

23145 During and immediately following implementation of MO3, waterfowl populations in the
23146 vicinity of the four dams would experience loss of shallow-water habitat and increased risk of
23147 predation. Several years after dam breaching, emergent herbaceous and forested and scrub-
23148 shrub habitats would establish along the new river channel and these habitats would increase
23149 compared to current conditions under the No Action Alternative. The then Washington
23150 Department of Game and USFWS (1984) estimated that approximately 120,000 pheasants,

23151 quails, and doves were displaced when the dams were constructed and forested wetland
23152 habitats were inundated. A series of isolated, irrigated habitat management units currently
23153 provide habitat for these species under the No Action Alternative. As forested wetlands
23154 become established along the new riverbanks, these areas would support breeding and
23155 foraging habitat for birds and populations would likely increase compared to No Action
23156 Alternative estimates. Once wetland and off-channel habitat become established along the
23157 banks of the river following implementation of MO3, this habitat would provide productive
23158 breeding, foraging, sheltering, and wintering habitat for waterfowl in the lower Snake River
23159 study area.

23160 The availability of island habitats would increase compared to conditions under the No Action
23161 Alternative. Approximately 50 islands, each greater than 5 acres, supported nesting habitat for
23162 Canada geese and were inundated behind the lower Snake River dams (Corps 1988;
23163 Washington Department of Game and USFWS 1984). These islands provide suitable habitat for
23164 nesting Canada geese and other waterfowl after vegetation and protective cover becomes
23165 established. If these islands develop suitable habitat to support waterfowl nesting and the
23166 islands are land-bridged, nesting waterfowl would experience increased risk of predation from
23167 mammalian predators. In 1976, Asherin and Claar found that decreased water surface
23168 elevations in the McNary reservoir exposed land bridges to Badger and Foundation Islands, as
23169 well as three of the five Hat Islands and coyote preyed on geese nesting on these islands.
23170 Conversely, if the islands were effectively isolated from the mainland, habitat would be more
23171 suitable for nesting waterfowl. In addition, the large sediment loads currently stored behind the
23172 four dams would provide source material for new sandbars and shallow-water areas as the river
23173 establishes a new thalweg.

23174 Wintering waterfowl would experience disturbance during dam breaching and individuals
23175 would relocate to other areas outside of the construction areas. Degraded water quality and
23176 sediment transport processes would limit aquatic prey resources and foraging success for
23177 waterfowl dependent on aquatic invertebrates and fish both during and immediately following
23178 dam breaching and reservoir drawdown. Habitat conditions would change from slow-moving
23179 reservoirs with submerged aquatic plants such as pondweeds and waterweeds, to a higher
23180 velocity riverine system that would minimize the potential establishment of submerged aquatic
23181 plants. Decreasing the quantity and distribution of submerged aquatic vegetation would
23182 decrease foraging resources for waterfowl and diving ducks like American coot and American
23183 widgeon (*Mareca americana*). As a result, waterfowl production on the lower Snake River
23184 would decline for several years after dam breaching. While vegetation growth on newly
23185 exposed mudflats would increase the availability of foraging habitat for individuals foraging on
23186 grasses, the combination of increased exposure to predators, heavy weedy growth, and
23187 unstable shorelines would create barriers to the river for young birds, and potentially result in
23188 adverse effects to birds for several years. The breaching of the dams would cause the decrease
23189 of lake habitat waterfowl, including scaups, mallard ducks, bufflehead, Barrows goldeneye,
23190 merganser, and benefit species that prefer river, riparian, and upland habitats such as yellow
23191 warbler.

23192 Once shallow-water habitats and wetlands begin to establish several years after the drawdown,
23193 the quantity, quality, and distribution of foraging habitat would increase compared to No
23194 Action Alternative conditions. However, in the intervening years between drawdown and
23195 habitat establishment, breeding, foraging, and winter waterfowl would likely relocate to other
23196 areas in the Pacific Flyway where resources are abundant. Some small wetlands would develop
23197 on newly formed islands resulting from sediment deposition.

23198 Implementing MO3 would increase the quantity of exposed mudflats available for foraging for
23199 migrating and resident shorebirds such as killdeer (*Charadrius vociferous*) and spotted
23200 sandpiper (*Actitis macularius*) compared to the No Action Alternative (Taylor and Trost 1992).
23201 However, this benefit would decrease as these mudflats become vegetated by wetland or
23202 upland plant communities. These habitats are unsuitable or less suitable for shorebird nesting.
23203 The seed bank along the lower Snake River has the potential to support rapid recolonization in
23204 the upper 15 feet of the existing reservoir (Robberecht 1998). During and immediately
23205 following dam breaching and reservoir drawdown, migratory shorebird abundance would
23206 fluctuate with changes in habitat availability and abundance of exposed mudflats. Abundance
23207 and species richness would return to current estimates as habitats stabilize over time.

23208 While colonial nesting waterbirds are present in the Columbia River Basin and individuals forage
23209 along the lower Snake River, nest colonies are uncommon in Region C. Under MO3, dam
23210 breaching and reservoir drawdown would increase the quantity of exposed areas and islands
23211 available as nesting habitat for species such as Caspian tern (*Hydroprogne caspia*), double-
23212 crested cormorant (*Phalacrocorax auritus*), American white pelican (*Pelecanus*
23213 *erythrorhynchos*), and numerous gulls. Prey resources in the lower Snake River for fish-eating
23214 water birds would decrease during and immediately following dam breaching. However, model
23215 results for fish populations suggest an increased abundance of returning adult salmon and
23216 steelhead populations several years after dam breaching. As a result, the abundance of juvenile
23217 fish produced by these returning adults is expected to increase. However it should be noted
23218 that upon the breaching of the lower Snake River dams, Bonneville would no longer have an
23219 obligation to fund U.S. Fish and Wildlife Service for the operations and maintenance of the
23220 Lower Snake River Compensation Plan hatchery facilities, because Bonneville's funding
23221 authority is directly tied to the operation of the lower Snake River dams. This could result in
23222 fewer hatchery juvenile fish being released into the lower Snake River from these facilities,
23223 however the co-lead agencies recognize that transitional needs will be addressed as the
23224 effectiveness of dam breaching is assessed (see further discussion in Section 3.5.3.6).

23225 In addition, the large quantity of sediment stored behind the four dams would provide source
23226 material for sandbars and shoreline habitat to support nesting waterbirds like gulls and terns.
23227 As shorelines become vegetated, habitat suitability for nesting would decrease. In contrast to
23228 gulls and terns, the development and growth of woody vegetation would support nesting
23229 habitat for herons and other waterbirds that are not present above Ice Harbor Dam (Rocklage
23230 and Ratti 1998; Corps 1999). Based on observations of nesting waterbirds before the dams
23231 were constructed, double-crested cormorants may use habitats as they develop features

23232 develop which support roosting or nesting (Weber and Larrison 1977). This would be different
23233 from current conditions where cormorants are not observed nesting in the lower Snake River.

23234 Raptors like northern harrier (*Circus cyaneus hudsonius*), red-tailed hawk (*Buteo jamaicensis*),
23235 and owls which are associated with wetlands, would experience a reduction in breeding,
23236 nesting, and perching habitat. They would also be affected by changes in the availability of prey
23237 resources as forested wetlands transition to drier, upland habitats following drawdown. As
23238 small mammal populations and water birds respond to habitat loss and populations shift to
23239 areas outside of the drawdown area in the years after dam breach and drawdown, raptors
23240 would have to shift to other prey resources. As wetland habitats become established along the
23241 new river channel, raptor populations would respond to increases in prey resources over time.
23242 In addition, as rocky habitats and cliffs are exposed following drawdown, nesting habitat for
23243 falcons and other cliff-nesting raptors would increase compared to current conditions under
23244 the No Action Alternative. Owls and other cavity-nesting raptors would benefit from the
23245 development of snags where the existing reservoir shorelines provide mature trees.
23246 Approximately 12,500 acres of upland habitat would increase the availability of open hunting
23247 space for species such as American kestrel (*Falco sparverius*) and northern harrier. As forested
23248 wetland habitats become established over time, mature trees would provide nesting sites for
23249 fish-eating raptors like osprey. Overall, there would be long-term increases in fish-eating
23250 raptors, especially, because there would be better and more perch sites available, as well as
23251 more exposed mud flats. In the short term, there may be some losses of perch sites, however.

23252 In Region C, wetland habitats adjacent to the reservoirs support the highest species diversity
23253 and overall abundance of birds compared to other habitat types (Asherin and Claar 1976;
23254 Rocklage and Ratti 1998). The loss of approximately 160 acres of emergent herbaceous
23255 wetlands and an additional 1,200 acres of forested and scrub-shrub wetland habitats from
23256 reservoir drawdown would adversely impact a wide variety of birds by reducing the quantity,
23257 quality, and distribution of breeding and foraging habitat for migratory songbirds like orioles,
23258 sparrows, flycatchers, and warblers, raptors like Cooper's hawk (*Accipiter cooperii*) and
23259 northern harrier, and owls like western screech and great horned (Rocklage and Ratti 1998). As
23260 wetland habitats become established along the new river channel, the quantity, quality, and
23261 distribution of habitats supporting breeding and foraging habitat would increase and may
23262 exceed current habitat conditions. It would take 20 to 50 years before forested wetlands have
23263 mature deciduous trees and a diversity of structure to support a diverse assemblage of
23264 migratory songbirds, raptors, and owls. Emergent herbaceous wetlands would develop along
23265 shorelines and off-channel areas of the new river channel, supporting marsh birds like wrens,
23266 blackbirds, and wading water birds.

23267 MO3 would adversely affect reptiles and amphibians during and immediately following dam
23268 breaching and reservoir drawdown. Reptiles are generally more mobile than amphibians and
23269 less dependent on aquatic habitat, with the exception of turtles. The Chief Timothy habitat
23270 management unit supports an isolated population of western painted turtles (*Chrysemys picta*
23271 *belli*) which would be lost as habitat management unit habitats transition to drier, upland
23272 habitats following drawdown. The permanent reduction in water surface elevations and loss of

23273 riparian and wetland habitats would isolate amphibian populations, desiccating eggs or
23274 juveniles that are not able to relocate to adjacent wetland habitats. Loper and Lohman (1998)
23275 experimentally showed that amphibian eggs exposed to desiccation for approximately one day
23276 are no longer viable. Amphibian populations would therefore experience population-level
23277 declines following a widespread, generational loss of eggs and juveniles along some stretches of
23278 the river. Over time, however, the species assemblages would reestablish along the new river
23279 channel as shallow water habitats, emergent herbaceous, and forested and scrub-shrub
23280 wetlands become established. Over time, contiguous wetland habitats would improve habitat
23281 connectivity to support dispersal and movement for reptiles and amphibians, supporting overall
23282 improvements to habitat quantity, quality, and distribution compared to the No Action
23283 Alternative.

23284 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

23285 Nine structural measures are associated with MO3 in Region D: Additional Power Surface
23286 Passage, *Fewer Fish Screens*, *Upgrade to Adjustable Spillway Weirs*, *Modify Bonneville Ladder*
23287 *Serpentine Weir*, *Lamprey Passage Structures*, *Turbine Strainer Lamprey Exclusion*, *Bypass*
23288 *Screen Modifications for Lamprey*, *Lamprey Passage Ladder Modifications*, and *Improved Fish*
23289 *Passage Turbines*. These structural measures are not expected to result in widespread effects to
23290 floodplains, wildlife habitats, or populations.

23291 Under MO3, there would be no changes to the reservoir elevations at McNary, The Dalles, or
23292 Bonneville Dam. At John Day Dam, the *John Day Full Pool* measure calls for operating the
23293 reservoir between 1.5 to 2.5 feet higher than the No Action Alternative from March 15 to
23294 September 30. Operational measures associated with MO3 in Region D are *Spring Spill to 120%*
23295 *TDG*, *Reduced Summer Spill*, *Ramping Rates for Safety*, *John Day Full Pool*, *Above 1% Turbine*
23296 *Operations*, and *Contingency Reserves in Fish Spill*. See Sections 3.2, *Hydrology and Hydraulics*,
23297 for greater detail on changes to sediment transport process and hydrology under MO3, and
23298 corresponding changes to these resources following dam breaching. Implementing the
23299 structural and operational dam breaching measures in Region C in concert with the *John Day*
23300 *Full Pool* measure would impact wildlife habitats and populations in Lake Umatilla. Between
23301 Bonneville and John Day Dams, changes in pool elevations are negligible, and river conditions in
23302 Lake Bonneville and Lake Celilo do not change measurably from the No Action Alternative,
23303 resulting in no expected changes to wildlife habitats in these areas. Downstream of Bonneville
23304 Dam, water levels change slightly immediately downstream of the dam, and details are
23305 provided below.

23306 Under MO3, the majority of sediment released from the reservoirs on the lower Snake River
23307 following embankment breaching would be deposited in Lake Wallula between the confluence
23308 of the Columbia with the Snake River and Wallula, Washington. In the near term, within the
23309 Snake River corridor sediments would deposit along newly exposed shorelines and would
23310 support the development of emergent herbaceous and forested and scrub-shrub wetlands. As
23311 sediments are transported by the Snake River, they are expected to accumulate within the
23312 lower subreach near the confluence of the Columbia and the Snake River (see Appendix C, *River*

23313 *Mechanics*). Most of the sediment would settle along the channel margins, however, sediment
23314 deposition would also occur along the banks of the Columbia River and deposits could be 5 to
23315 15 feet in depth. However, because the McNary Reservoir is greater than 20 feet deep, most
23316 sediment deposition in the Columbia River channel would lie below the average water surface
23317 elevation and would not develop into vast wetland complexes. Over the long term, watershed
23318 sediment loads would also be routed to the confluence area.

23319 Any exposed sediment would increase mudflats and potentially establish as invasive plant
23320 species to spread and become established as they spread into areas where they do not occur
23321 under the No Action Alternative. The overall distribution and quantity of invasive species in
23322 upper portions of Region D above McNary Dam would likely increase under MO3, which would
23323 result in a reduction of habitat quality for a suite of wildlife until native species become
23324 established. To offset this effect the co-lead agencies are proposing to plant approximately 155
23325 acres of emergent and forested scrub-shrub wetland habitats on the Columbia River
23326 downstream of the confluence with the Snake River and to excavate newly deposited soils on
23327 the 155 acres to maintain the hydrologic conditions necessary to support wetland habitats is
23328 proposed to offset this effect. As a result, the overall distribution and quantity of invasive
23329 species in the lower portion of Region D below Bonneville Dam is not expected to increase
23330 under MO3 compared to the No Action Alternative and therefore no changes to wildlife
23331 populations are expected due to effects of operations of the CRS on invasive species. Where no
23332 management efforts are implemented, invasive species are expected to persist under MO3
23333 similar to the No Action Alternative.

23334 Similar to the effects described in MO1, forested and scrub-shrub and emergent wetlands in
23335 Lake Umatilla would be impacted by the increased water surface elevations in April and May
23336 under MO3, including the extensive wetland complex at the Umatilla National Wildlife Refuge.
23337 Prolonged inundation during the early part of the growing season would result in a 40 percent
23338 expansion of shallow water habitat, an expansion of wetland plant communities, or shift the
23339 composition of plants to species more tolerant of prolonged inundation. If the overall quantity,
23340 quality, and distribution of emergent herbaceous and forested and scrub-shrub wetlands
23341 expand under MO3 compared to the No Action Alternative, wetland habitats are expected to
23342 increase overall productivity in Lake Umatilla, supporting breeding amphibians, reptiles,
23343 mammals, and birds during the spring and summer breeding season. Improved wetland
23344 habitats would also support regionally important migratory waterfowl overwintering in the
23345 Umatilla NWR Important Bird Area by increasing forage opportunities and prey resources.

23346 Over time, shallow-water habitats and wetlands would begin to establish several years after the
23347 drawdown, the quantity, quality, and distribution of foraging habitat would increase compared
23348 to No Action Alternative conditions. However, in the intervening years between drawdown and
23349 habitat establishment, breeding, foraging, and winter waterfowl would likely relocate to other
23350 areas in the Pacific Flyway where resources are abundant. Individuals would move from the
23351 lower Snake River to Lake Umatilla and Lake Wallula on the Columbia River near John Day and
23352 McNary Dams, however, shallow-water habitats in these areas would similarly experience
23353 sediment deposition, which would decrease food resources. Over 50 percent of sediments

23354 trapped behind the four dams would be deposited north of Wallula Gap along the left river
23355 bank in and adjacent to the McNary National Wildlife Refuge (see Appendix C for details about
23356 River Mechanics) over approximately 14,600 acres of the reservoir, including approximately 155
23357 acres of adjacent forested and scrub-shrub and emergent wetlands. It is unknown how or if this
23358 deposition would affect waterfowl displaced from the Snake River reservoirs; however, where
23359 the quantity and quality of wetlands decrease after dam breaching, waterfowl and other
23360 wildlife populations would be displaced from the immediate area until habitat reestablishes in
23361 the years following the second phase of dam breaching.

23362 Downstream of John Day, changes in minimum water surface elevations under MO3 are
23363 consistent with the natural range of variability and fluctuations from daily operations.
23364 Consequently, the quantity, quality, and distribution of habitats would not deviate measurably
23365 from the No Action Alternative. As a result, implementing MO3 would not result in a conversion
23366 of habitats that would measurably affect wildlife populations.

23367 Minor reductions in flood elevations would occur below Bonneville Dam for floods that occur
23368 with moderate frequency, which could have minor effects on floodplain benefits in this region.
23369 On average, changes in river levels downstream of Bonneville Dam would be less than 3 inches
23370 and within the natural range of variability in daily water levels. For this reason, MO3 is not
23371 expected to cause measurable effects to wildlife populations or their habitats downstream of
23372 Bonneville Dam. The lower portions of the Columbia River would continue to support valuable
23373 habitat for fish and wildlife, and current trends are expected to continue.

23374 In locations where ODFW or WDFW manage wetland habitats for wildlife, operations and
23375 maintenance actions under MO3 are assumed to continue similar to current practices under the
23376 No Action Alternative, including actions at Klickitat Wildlife Area and Sondino Ponds in
23377 Washington State for western pond turtles. It is assumed that wildlife concentrations and use of
23378 habitats in the lower Columbia River and Columbia River estuary would not change under MO3
23379 from current conditions as described in the No Action Alternative.

23380 The fish modeling for MO3 indicates juvenile salmon and steelhead have a higher survival
23381 compared to the No Action Alternative and fish would move through the system faster
23382 compared to No Action Alternative conditions. Water quality throughout the lower Columbia
23383 River would be poor for several years after dam breaching and turbidity would be high during
23384 the spring freshet. These conditions decrease foraging opportunity and success for fish-eating
23385 birds, which would influence reproductive success for the colonies. As a result, existing nesting
23386 colonies would shrink or move to other locations in the region until habitats become
23387 established and turbidity inputs decrease over time.

23388 Hydrology and hydraulics model results do not show measurable changes in water surface
23389 elevations in Lake Umatilla, with the exception of an increase in pool elevations in April and
23390 May by as much as 2.5 feet compared to the No Action Alternative from implementing the *John*
23391 *Day Full Pool* measure. The effects of this measure would be consistent with the effects
23392 described in greater detail for the *Predator Disruption Operations* measure under MO1. In

23393 general, nesting habitat including on Blalock Island, for colonial nesting water birds like terns
23394 and gulls, would be inundated during the early part of the breeding season when birds typically
23395 initiate nesting activities. These effects are consistent with effects described in the MO1
23396 *Predator Disruption Operations* measure. Consequently, birds would delay breeding until later
23397 in the summer when pool elevations decrease and expose suitable nesting habitat or relocate
23398 to other areas within and outside the Columbia River Basin.

23399 **FLOODPLAINS**

23400 Under MO3, changes in flood elevations would typically be negligible (absolute value less than
23401 0.3 feet) across the Columbia River Basin for all flood frequencies, from regularly occurring
23402 floods (AEP of 50 percent) to the base flood (AEP of 1 percent). However, major changes in the
23403 floodplain would occur in Region C for the lower Snake River (below Dworshak Dam) under the
23404 *Lower Snake Infrastructure Drawdown* measure. The changes in river width, depth, and velocity
23405 resulting from this measure, as described in Appendix B, Part 1, *H&H Data Analysis*, would have
23406 large, short-term effects on the floodplain. In the long term, this alternative would be expected
23407 to ultimately restore the floodplain to a more natural condition. Over time, these changes
23408 would have a major, beneficial effect on floodplain values in the Snake River below Dworshak
23409 Dam.

23410 **SPECIAL STATUS SPECIES**

23411 This section discusses the potential effects of implementing MO3 on ESA-listed plant and
23412 animal species that may occur in the study area.

23413 Implementing MO3 would indirectly benefit wintering bald eagles by increasing the availability
23414 of stranded salmon and other fish prey as water levels recede during the period of
23415 deconstruction. In the near term, trees used for roosting and nesting would decline as habitats
23416 transition following changes to water surface elevations. Over time, however, large trees could
23417 develop along the river channel and these trees would improve habitat conditions along the
23418 lower Snake River for eagles.

23419 As described in Section 3.5, the fish models predict a moderate to major increase in smolt-to-
23420 adult returns and overall abundances of adult salmon and steelhead over the long term. There
23421 may be short-term adverse effect as a result of dam breach efforts that may cause disruption in
23422 foraging behavior of marine mammals and colonial nesting birds. Over the long term, this
23423 would lead to an increase the prey base available to marine mammals foraging in the Columbia
23424 River, such as seal or sea lion, or offshore from the mouth of the Columbia River, such as killer
23425 whale. This overall effect is moderate to major for sea lions and minor for Southern Resident
23426 killer whales (Table 3-106).

23427 Table 3-106. Sensitive Species Analysis for MO3

Common Name	Scientific Name	Status of Species and Critical Habitat	Projects Where Species Occurs	Effects of MO3
Mammals				
Grizzly bear	<i>Ursus arctos horribilis</i>	ESA status: T CH: proposed	Libby Dam Hungry Horse Dam	Construction of structures on the dam: No effect. No structures are proposed under MO3. Bears are spatially removed from the dam projects. Hydrology: Negligible effect. Altering riparian vegetation to drier vegetation (e.g., conifers) at Libby Dam. No effects to the species at Hungry Horse Dam study area. Conclusion: Negligible effect: MO3 effect to grizzly bear is similar to NAA. MO3 is not likely to adversely affect the grizzly bear.
Columbian white-tailed deer	<i>Odocoileus virginianus leucurus</i>	ESA status: T CH: None	Downstream of Bonneville Dam	Construction of structures on the dam: No effect. No structures proposed and disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Water surface elevation changes minimal (less than 0.5-foot difference) and within range of natural variation. Not likely to convert suitable habitat or flood individuals. Conclusion: Negligible effect: MO3 effect to Columbia white-tailed deer is similar to NAA. MO3 is not likely to adversely affect the Columbia white-tailed deer.
California sea lion	<i>Zalophus californianus</i>	ESA status: None CH: None Marine Mammal Protection Act	Downstream of Bonneville Dam, occasionally to The Dalles Dam	Construction of structures: No effect: No Temporary, minimal visual and noise disturbance. Hydrology: Negligible Effect. Water surface elevation changes minimal (less than 1-foot difference) and within range of natural variation. Prey availability: Moderate-to-major effect. Moderate to major decrease in the short term in response to dam breaching and overall moderate to major increase in prey availability over the long term beyond to NAA conditions. Conclusion: Moderate-to-major effect. Hazing would be moderately to majorly higher than NAA. Overall population of California sea lions would remain stable.
Steller sea lion	<i>Eumetopias jubatus</i>	ESA status: None CH: None Marine Mammal Protection Act Protected	Downstream of Bonneville Dam	Construction of structures on the dam: No effect. Temporary, minimal visual and noise disturbance, potentially resulting in avoidance of the area. Hydrology: Negligible effect. Water-surface elevation changes minimal (less than 1-foot difference) and within range of natural variation. Prey availability: Moderate-to-major effect. Moderate to major decrease in the short term in response to dam breaching and overall moderate to major increase in available prey over the long term beyond NAA conditions. Conclusion: Negligible effect. Hazing may decrease initially and then be moderately to majorly higher than NAA over the long term. Overall population of Steller sea lions would remain stable.
Southern Resident Killer Whale DPS	<i>Orcinus orca</i>	ESA status: E CH: None	None	Construction of structures on the dam: No effect. Disturbance would not extend to suitable habitat for Southern Resident killer whales, no individuals or habitat affected. Hydrology: Negligible effect. Water surface elevation changes minimal (less than 0.5-foot difference) and within range of natural variation. Prey Availability: Minor effect. The Snake River spring/summer Chinook salmon is a negligible portion of their overall diet. Fish models do predict that lower Snake River Chinook salmon smolt-to-adult returns would increase under MO3. Operation of all fish hatcheries is uncertain. There may be short-term negative effects to the Southern Resident killer whale population as the lower Snake River fish population recovers from effects associated with dam breaching. Overall, prey should increase beyond NAA over the long term. This overall effect could change Southern Resident killer whale distinct population segment behavior both over the short and long term as whales react to the changes in prey availability. Conclusion: Minor effect. The food available to Southern Resident killer whales from the lower Snake River population is only a small percentage of their overall diet. Changes to food availability may change the whale's foraging behavior patterns slightly but will not change their overall condition or population dynamics. MO3 is not likely to adversely affect the Southern Resident killer whale distinct population segment.
Birds				
Yellow-billed cuckoo	<i>Coccyzus americanus</i>	ESA status: T CH: Proposed	Study area is within the range of yellow-billed Cuckoo.	Construction of Structures on the dam: No effect. Disturbance would not extend to suitable habitat; no individuals or habitat affected. Hydrology: Moderate effect to suitable habitat. Water fluctuations at Libby Dam would result in high winter flows that prevent establishment of cottonwoods galleries. Within Regions A, B, & D, the water surface elevation changes are minimal (less than 1-foot difference) and within range of natural variation. Not likely to convert suitable habitat or flood individuals. Region C cottonwoods may be temporarily disrupted due to changes in water surface elevations of 80 to 100 feet. Patches of cottonwoods may establish in confluence of tributaries over the long term. Conclusion: Moderate effect to suitable habitat. MO3 operations will continue trends of reduced riparian habitat suitable for Yellow-Billed Cuckoo at Libby. No effect from operations under MO3 for Region B and D projects. Drawdown of the Snake River would result in temporarily reducing cottonwood and reestablishing the cottonwoods in confluence of tributaries. MO3 is not likely to adversely affect the yellow-billed cuckoo.

Common Name	Scientific Name	Status of Species and Critical Habitat	Projects Where Species Occurs	Effects of MO3
Bald eagle and Golden eagle	<i>Haliaeetus leucocephalus</i> <i>Aquila chrysaetos</i>	Bald and Golden Eagle Protection Act	Throughout the study area.	Construction of structures on the dam: Negligible effect. Hydrology: Negligible effect. MO4 operations would reverse trends in reducing riparian habitat along the Kootenai River. With improved riparian function. Bald eagles would nest in mature cottonwood trees. Overall, cottonwoods could continue to decline in areas where cottonwoods have established. Conclusion: Negligible effect. Forested areas should remain forested along the riparian system. Therefore, the effect to bald and golden eagles should be negligible in compared to NAA. MO3 would not likely adversely affect the bald or golden eagle populations.
Streaked horned lark	<i>Eremophila alpestris strigata</i>	ESA status: T CH: Designated	Downstream of Bonneville Dam	Construction of Structures on the Dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: No effect. Water surface elevation changes are minimal (less than 0.5-foot difference) and within range of natural variation. Not likely to convert suitable habitat or flood individuals. Conclusion: No effect from operations under MO3. MO3 would not likely adversely affect streaked horned lark.
Plants				
Ute Ladies'-tresses	<i>Spiranthes diluvialis</i>	ESA status: T CH: None	Grand Coulee Dam Chief Joseph Dam	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Grand Coulee: Changes in water surface are minimal and therefore, would not alter regions along the water margins where the plant occurs. Conclusion: No effect. Grand Coulee hydrology under MO3 would be similar to NAA and would not have a negative effect on the plant, if the plant were to occur along the banks and margins of Lake Roosevelt. MO3 would not likely adversely affect Ute ladies'-tresses.

23428 Note: C = Candidate for listing; CH = Designated for Critical Habitat; E = Endangered; T = Threatened.

23429 **SUMMARY OF EFFECTS**

23430 Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue,
23431 including protection, mitigation, and enhancement of wildlife habitat as discussed in Section
23432 5.2.1. The effect of MO3 could be summarized by region, as follows.

23433 In Region A, under MO3, water surface elevations on Lake Koochanusa would be decreased in
23434 winter and spring, and increased in late summer which would result in changes in the barren
23435 zone, emergent herbaceous, and forested and scrub-shrub wetland habitats adjacent to the
23436 reservoir. Because pool elevations would be lower for the majority of the growing season,
23437 wetland habitats would transition into upland habitats or plant communities. MO3 operations
23438 would support exposure of island habitats and development of nesting habitat in the spring and
23439 summer in Lake Koochanusa. Downstream of Libby Dam, high winter flows in the Kootenai River
23440 would inundate riverbanks and redistribute seeds from forested wetland vegetation. Higher
23441 water levels in the winter would increase bank sloughing and erosion, potentially degrading
23442 water quality for aquatic wildlife. Lower spring flows would reduce moisture content of soils,
23443 which would reduce the suitability of shoreline habitat in the spring and summer for seed
23444 deposition and plant establishment.

23445 Also in Region A, the marginal changes in water flows and elevations downstream of Hungry
23446 Horse Reservoir, along the South Fork Flathead River from implementing MO3 would not alter
23447 floodplains, wetland habitats, vegetation communities, or wildlife populations compared to the
23448 No Action Alternative. Changes in water surface elevations and ramping rates during the
23449 western grebe colony breeding season in Denton Slough downstream of the Albeni Falls Dam
23450 could destabilize floating nests and cause them to break apart or become unstable. As a result,
23451 grebes would experience increased rates of egg loss and juvenile mortality, decreasing overall
23452 reproductive success. Overall, for Region A, there would be a moderate effect on wetlands,
23453 vegetation, habitat, and wildlife and a negligible effect to floodplains under MO3.

23454 In Region B, the measures under MO3 would have negligible effects on floodplains, quantity,
23455 quality, and distribution of habitats and, therefore, low potential for negative effects to wildlife
23456 populations and a negligible effect to floodplains.

23457 In Region C, MO3 dam breaching would result in the greatest wildlife, vegetation, wetland, and
23458 floodplain habitat effects. Dam breaching would result in a substantial change to the character
23459 of vegetation and wetlands along the Snake River between its confluence with the Clearwater
23460 River and its mouth where it flows into the Columbia River. Previously inundated areas would
23461 have vegetation permanently established, though the unvegetated soils in the previously
23462 inundated reservoir areas would be at increased risk of invasive species establishment. About
23463 1,200 acres of woody vegetation would be lost along the existing shorelines of the reservoirs,
23464 but hundreds of acres of new habitat types, such as rocky outcroppings, would be added. Some
23465 wildlife species would benefit from the conversion of habitat while the changes in vegetation
23466 and habitat would have a negative effect on other species. Overall, the short-term effect of
23467 MO3 on Region C would be negligibly beneficial and would have major negative effects on

23468 vegetation, wildlife, wetlands, and habitats. In the long term, this alternative could ultimately
23469 restore the floodplain to a more natural condition, which would have a major, beneficial effect
23470 on floodplain values in the Snake River below Dworshak Dam. Long-term effects to wildlife and
23471 vegetation could be a major effect, as wildlife and vegetation would need to respond to
23472 sediment and major changes to hydrology. With mitigation efforts and implementation of an
23473 invasive species management plan, the overall long-term effect could be beneficial.

23474 In Region D, sediments released during and after dam breaching would deposit along newly
23475 exposed shorelines and would support the development of emergent herbaceous and forested
23476 and scrub-shrub wetlands. Any wetlands impacted by sediment deposition following dam
23477 breaching would be mitigated to offset impacts to the overall quantity, quality, and distribution
23478 of emergent herbaceous and forested and scrub-shrub wetlands upstream of McNary Dam. As
23479 a result, there may be short-term impacts to breeding amphibians, reptiles, mammals, and
23480 birds during the spring and summer breeding season until wetlands become re-established in
23481 the years following dam breaching. For those areas downstream of McNary Dam, minimum
23482 pool elevations would not change from normal operations under the No Action Alternative.
23483 Consequently, MO3 is not expected to influence the quantity, quality, or distribution of habitats
23484 downstream of McNary Dam, and therefore, these changes are not expected to result in
23485 substantive or widespread changes to wildlife populations. Annual average probability of
23486 inundation would be unchanged from current conditions, with negligible effects on floodplains.
23487 Overall, the effect of MO3 on Region D would be negligible.

23488 For special status species in all regions, multiple special status species would be impacted by
23489 MO3 beyond No Action Alternative conditions. Overall, there would be negligible effect on
23490 special status species.

23491 **3.6.3.6 Multiple Objective Alternative 4**

23492 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

23493 No structural measures would be implemented in Region A under MO4 and, therefore, the
23494 proposed structural measures would not impact floodplains, wildlife habitats, or populations.
23495 Under MO4, operational measures are *McNary Flow Target*, *Sliding Scale at Libby and Hungry*
23496 *Horse*, *Modified Draft at Libby*, *December Libby Target Elevation*, *Hungry Horse Additional*
23497 *Water Supply*, and *Winter Stage for Riparian*. Collectively, these measures would influence
23498 operations in portions of Region A by altering draft and refill procedures at Libby and Hungry
23499 Horse, modify winter draft targets, and summer drafting (similar to measures proposed under
23500 MO1). Additionally, MO4 proposes to implement additional operations at Libby, Hungry Horse,
23501 and Albeni Falls to augment flows at McNary Dam and support growth and establishment of
23502 forested and scrub-shrub wetland habitats near Bonners Ferry, Idaho, by limiting outflow from
23503 Libby in the winter. Annual average probability of inundation is expected to remain unchanged
23504 from current conditions in Region A, with negligible effects on floodplains.

23505 As discussed in Section 3.2, *Hydrology and Hydraulics*, pool elevations in Lake Koocanusa are
23506 generally higher under MO4 during mid-winter and mid-summer and generally lower during

23507 spring drawdown and late summer through early winter after refill compared to the No Action
23508 Alternative. The primary habitat type affected by implementing the *December Libby Target*
23509 *Elevation* measure is the barren zone, and the measure delays the draft to start in January
23510 compared to December under the No Action Alternative. Effectively, this delay in drawdown
23511 results in higher pool elevations through mid-February, but the greatest increase occurs in
23512 December when the pool is approximately 9 feet higher. Because this change in timing does not
23513 occur during the growing season or exceed the range of pool fluctuations the reservoir
23514 currently experiences, the *December Libby Target Elevation* measure does not result in
23515 widespread changes to the quantity, quality, or distribution of habitats or floodplains in the
23516 study area. The effects are similar to MO1.

23517 When the *December Libby Target Elevation* is combined with the *Modified Draft at Libby*
23518 measure, the reservoir is drafted approximately 2 feet deeper in April, and summer refill
23519 increases pool elevations by approximately 1 to 1.5 feet. This increase during June and July
23520 would initiate vegetation establishment in the barren zone, which would support the
23521 establishment of emergent herbaceous wetlands in Lake Kootenai and increase the overall
23522 quantity of wetland habitats compared to operations under the No Action Alternative.
23523 Increased summer water levels would also increase the functional quality of existing wetlands
23524 where they occur near tributary confluences, such as the Tobacco River. However, lower pool
23525 elevations in the late summer (i.e., July through October) would negate this trend and even
23526 result in an overall decrease in wetland habitats if they transition to uplands or if plant
23527 composition shifts to species more tolerant of dry conditions or drought. During average water
23528 years, pool elevations are 3 to 6 feet lower in the late summer, substantially lower (5 to 12 feet)
23529 in low water years. Libby elevations vary greatly according to the annual forecast; in high water
23530 events, the pool elevation is up to 5 feet higher during August and September. Changing the
23531 pool elevations would result in a loss of emergent vegetation to open water. Furthermore,
23532 abrupt decreases in water levels in Lake Kootenai during middle and late summer are unlikely
23533 to affect nesting songbirds and waterfowl because young songbirds are mostly fledged by this
23534 time and young waterfowl have left the nest and are spending most of their time on the water.
23535 However, these decreases in water levels may expose young waterfowl to increased predation
23536 if they are forced to leave emergent vegetation and move into open water.

23537 The changes proposed for Libby under MO4 occur both during and outside of the growing
23538 season. Changes in water levels during the growing season would alternately inundate and dry
23539 narrow bands of emergent vegetation, which influence aquatic and terrestrial wildlife. For
23540 example, the Kootenai Falls WMA has approximately 3 miles of river frontage, and the Kootenai
23541 NWR supports emergent herbaceous and forested and scrub-shrub wetlands adjacent to the
23542 river. While the Kootenai Falls WMA is managed for mule and white-tailed deer and bighorn
23543 sheep that would unlikely be impacted by changes in river levels, changes in river levels would
23544 convert wetland habitats adjacent to the river to forests or other upland habitat types (MFWP
23545 2016). A conversion of wetlands to drier, upland habitat types would influence wetland-
23546 dependent species that would relocate to areas with suitable wetland habitat.

23547 Wildlife partially or entirely dependent on wetland habitats for part their lifecycle could be
23548 impacted by the conversion of wetland habitats to drier forests or upland habitat types. Where
23549 possible, wildlife would relocate to other areas or shift to higher elevations to avoid inundation
23550 when river levels are higher than No Action Alternative conditions. Conversely, species that are
23551 entirely dependent on wetlands would be seasonally impacted by fluctuations in river levels. As
23552 temperatures begin to warm in the spring, changing river levels would influence habitat
23553 suitability for breeding birds and amphibians, impacting long-term phenology and fecundity.
23554 Off-channel habitat may dry intermittently during the growing season, which would desiccate
23555 amphibian tadpoles, such as those of the western toad. Aquatic invertebrates such as
23556 caddisflies and stoneflies larvae would experience similar interruptions in their lifecycle and
23557 over time, these interruptions could lead to changes in food web ecology and overall ecosystem
23558 function.

23559 Implementing operational measures included in MO4 would cause notable changes in outflow
23560 from Libby and corresponding changes in river conditions on downstream portions of the
23561 Kootenai River. These changes are evidenced throughout the study area, and changes are less
23562 influential downstream as tributaries contribute inflows. Changes on the Kootenai River occur
23563 in winter as a result of the *Winter Stage for Riparian* and *McNary Flow Target* measures. High
23564 flows in June and July, followed by gradually receding water levels in subsequent months, allow
23565 for seedling establishment along the banks of the river. Implementing MO4 would lower water
23566 levels in the winter and reduce the likelihood of high water carrying seedlings downstream
23567 between November and March. The *Winter Stage for Riparian* measure would reduce the
23568 amount of time that flows inundate riverbanks by approximately 15 to 25 percent, thereby
23569 allowing tree and shrub seed germination and seedlings to become firmly established early in
23570 the growing season before the high flows flush through the system in June and July. As woody
23571 vegetation becomes established along the Kootenai River, the quantity, quality, and distribution
23572 of forested and scrub-shrub wetland could increase and support a wide variety of aquatic and
23573 terrestrial wildlife. This measure could reverse the trend of widespread losses in the quantity
23574 and distribution of cottonwood galleries along the Kootenai River within the active floodplain
23575 (KTOI 2013).

23576 Reduced winter flows stemming from the *McNary Flow Target* and *Winter Stage for Riparian*
23577 measures would decrease bank sloughing and erosion at Bonners Ferry. Increasing the
23578 establishment and recovery of cottonwood galleries would increase canopy cover over the
23579 river, thereby increasing shade, lowering water temperatures, and increase species diversity
23580 and density of native wildlife. Increased shade over the river reduces water temperatures and
23581 supports fish and aquatic wildlife sensitive to high temperatures. Specifically, implementing the
23582 *Winter Stage for Riparian* measure is anticipated to improve aquatic habitat for species like
23583 white sturgeon and bull trout, as well as terrestrial habitat for species like western yellow-billed
23584 cuckoos.

23585 Furthermore, increased canopy cover over the water increases the input of detritus and organic
23586 materials supporting invertebrates and the food web. Increasing the quantity, quality, and
23587 distribution of forested and scrub-shrub wetland habitats downstream of Libby would increase

23588 migratory corridors or link habitats which are currently fragmented and may attract migrant
23589 cuckoos into developing habitats. Increasing the availability of forested wetland habitat in the
23590 Libby study area would have ecosystem-wide benefits, including improved wetland and
23591 floodplain function. Higher quality habitat would provide more resources per acre, supporting
23592 higher densities of native wildlife.

23593 After several years of implementing MO4 measures at Libby, habitat in the study area would
23594 stabilize, and the conversion of wetlands would create new boundaries between different
23595 habitat types. MO4 would not impact wildlife downstream of Libby and, while these changes
23596 would not be realized for several years or decades following implementation, long-term effects
23597 of the *Winter Stage for Riparian* measure would benefit wildlife. Operational changes at Libby
23598 under MO4 are also evident in downstream reaches of the Columbia River, as discussed in the
23599 sections on Regions C and D below.

23600 In regard to potential effects in Canada, the effects to vegetation and wildlife resources and
23601 their habitats under MO4 are expected to be similar to the effects described for the United
23602 States portion of Region A.

23603 Of all alternatives, MO4 results in the greatest differences at Hungry Horse for water surface
23604 elevations and outflows and the subsequent effects on vegetation and habitat. Water surface
23605 elevations in the reservoir would be lower throughout the year, with changes ranging from a
23606 decrease of approximately 1.0 to 6.0 feet in the summer to 6.0 to 12.0 feet in winter. Full pool
23607 would be reached about a week later in June than the No Action Alternative on average, and
23608 the reservoir would be drafted earlier in August. The decrease in the number of days when the
23609 reservoir is full during the growing season would result in drier conditions for wetlands and
23610 riparian vegetation around the reservoir. The productivity and growth of the narrow band of
23611 vegetation at or near high-pool elevation (3,558 to 3,559 feet NGVD29 [NAVD88]) would
23612 decrease, or plants would transition to species more tolerant of less water or drier conditions.
23613 These changes would result in an overall decrease in the quantity, quality, and distribution of
23614 wetland habitats in the narrow band of vegetation adjacent to the reservoir shorelines.

23615 The composition of vegetation in wetland habitats is expected to transition to species more
23616 tolerant of dry or drought conditions or may become upland habitat types over time. These
23617 changes would result in an overall decrease in the quantity, quality, and distribution of wetland
23618 habitats adjacent to the reservoir shorelines in the Hungry Horse study area. Wildlife
23619 populations would experience increased risk from predatory animals (i.e., wolf and mountain
23620 lion). In response to a loss of wetland habitats and associated vegetation around the reservoir,
23621 birds could be displaced from nesting or sheltering habitat in forested and scrub-shrub or
23622 emergent herbaceous wetland habitats and would likely relocate to other areas where suitable
23623 wetland habitat is available, which could increase competition for limited resources.

23624 In response to a loss of wetland habitats and associated vegetation around the reservoir, birds
23625 would be displaced from nesting or sheltering habitat in forested and scrub-shrub or emergent
23626 herbaceous wetland habitats adjacent to the reservoir and may be forced to relocate to other

23627 areas where suitable nesting habitat is available. This could lead to increased competition for
23628 limited resources.

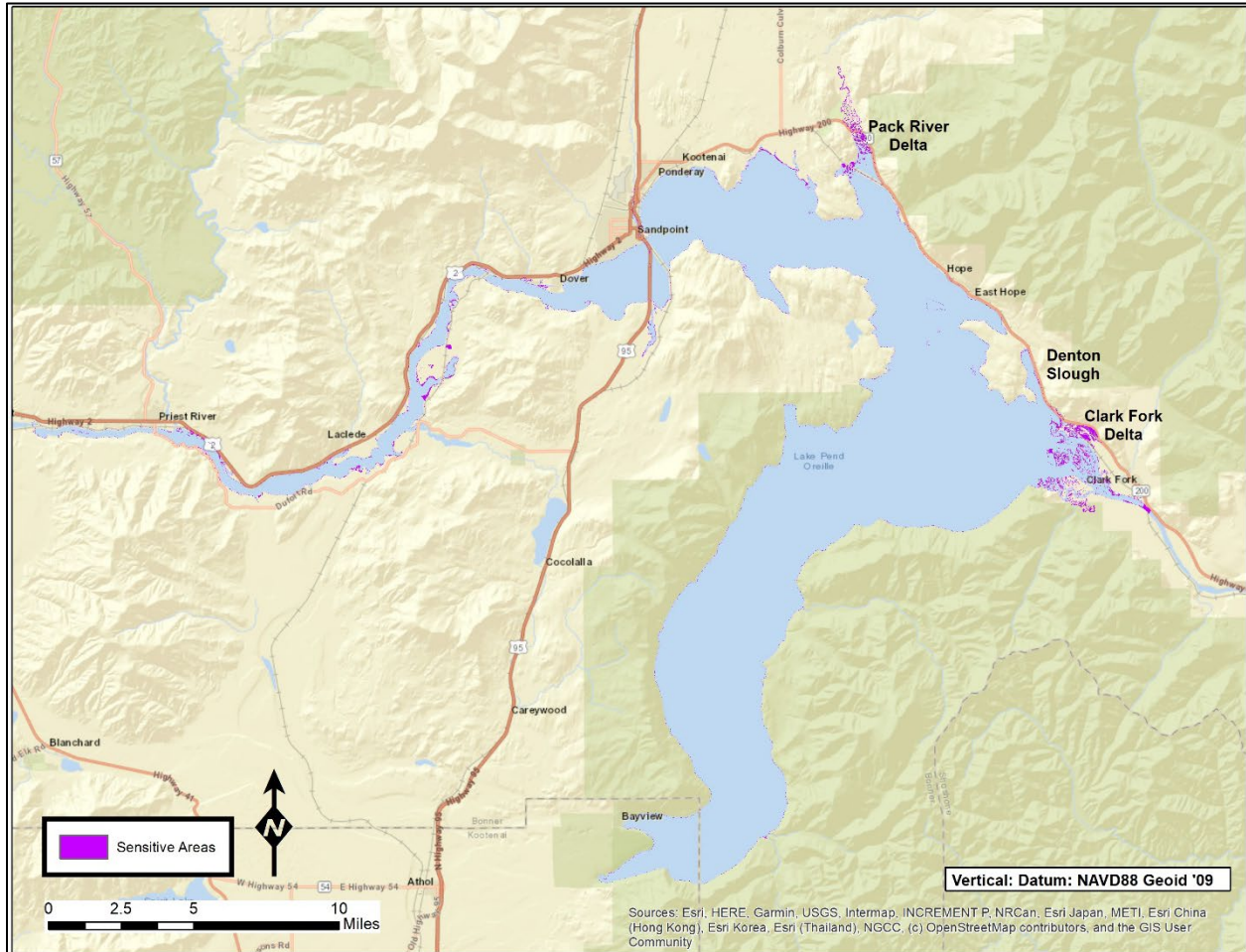
23629 Due to the delay in fill and the earlier drawdown, more of the barren area would be exposed
23630 and for longer periods compared to the No Action Alternative. Wildlife would experience
23631 increased risk of predation from predatory animals (i.e., wolf, mountain lion, and raptors) in
23632 late summer and fall. This would impact individuals but would not have population-level effects
23633 for small mammals or the predators.

23634 Implementing MO4 is not expected to result in noticeable changes downstream in the South
23635 Fork Flathead River. Water surface elevations during winter and spring would be slightly lower
23636 (0.2 to 0.4 feet) than the No Action Alternative, and summer conditions would be slightly higher
23637 (0.4 feet). Despite these changes, river conditions would be within the natural range of
23638 variability, and any differences are less than 6 inches compared to the No Action Alternative.
23639 Vegetation along the river would benefit slightly from more water during the later portion of
23640 the growing season. The functional quality of forested and scrub-shrub and emergent
23641 herbaceous wetlands would increase slightly as a result of a prolonged period of wetted
23642 conditions yielding higher productivity compared to the No Action Alternative. In response,
23643 these habitats would provide higher quality breeding, feeding, and sheltering conditions later in
23644 the growing season for a suite of wildlife species. Water levels would typically be within a few
23645 inches of those in the early part of the growing season under the No Action Alternative.
23646 Therefore, these habitats are not expected to transition from one type to another or to
23647 experience noticeable changes in plant composition.

23648 Below the confluence of the South Fork Flathead and Flathead Rivers, the effects from
23649 implementing MO4 at Hungry Horse would be negligible. Wildlife habitats and populations in
23650 the Flathead River would not measurably change from No Action Alternative conditions.

23651 At Albeni Falls Dam, the *McNary Flow Target* measure calls for additional water to be released
23652 from Albeni Falls Dam in the late spring and early summer to support fish passage conditions in
23653 the Lower Columbia River during drier years. Except as specified below, water surface
23654 elevations in Lake Pend Oreille and reaches of the Columbia River downstream of Albeni Falls
23655 would be unchanged from No Action Alternative conditions (described in greater detail in
23656 Section 3.2, *Hydrology and Hydraulics*). Implementing the *McNary Flow Target* measure would
23657 reduce water surface elevations in Lake Pend Oreille during the summer approximately by as
23658 much as 2.6 feet in dry years compared to the No Action Alternative; July and August would
23659 experience the greatest decrease in pool elevations, with smaller decreases occurring in June
23660 and September. The growing season in the Albeni Falls study area occurs from April through
23661 October. Because changes occur during the growing season, the habitats most likely impacted
23662 by this measure include mudflats, barren zones, and forested and scrub-shrub and emergent
23663 herbaceous wetlands, as well as islands with variable habitats. Wildlife species most likely to be
23664 affected include waterfowl; shorebirds; small and medium-sized mammals, including beaver
23665 and muskrat; amphibians; and insects.

23666 In the drier 50 percent of years, MO4 would expose mudflats and barren lands that are typically
23667 covered by water during summer under the No Action Alternative. Exposing these lands
23668 between elevations 2,059.7 and 2,062.5 feet NGVD29 (NAVD88) during the growing season
23669 would also result in the establishment and growth of emergent and shrubby vegetation,
23670 including non-native, invasive plant species (Figure 3-153). Recreational activities on Lake Pend
23671 Oreille include boating, which produces wakes that lead to erosion along barren zones and
23672 mudflats. In comparison with the No Action Alternative, implementing MO4 would expose an
23673 additional 1,200 acres of land to erosion during the summer (Figure 3-154).



23674
23675 **Figure 3-153. Map Showing Sensitive Areas Along the Lake Pend Oreille Shoreline**

23676 Note: These areas would experience exposed mudflats, conversion of wetland habitats, and extensive barren
23677 zones under MO4. These sensitive areas include shorelines within the Pack River Delta, Denton Slough, and Clark
23678 Fork Delta.

23679 Lower lake elevations would result in changes to emergent herbaceous and forested and scrub-
23680 shrub wetland vegetation similar to the effects described in Region A from implementation of
23681 the *McNary Flow Target* measure (Figure 3-155). Increasingly dry conditions would decrease
23682 the quantity, quality, and distribution of wetland habitats that occur at the lake shorelines, or
23683 these habitats would transition to upland habitat types or change the plant composition
23684 compared to current conditions. Conversely, portions of the barren zone would transition to

23685 wetland habitats under MO4 where emergent vegetation becomes established because water
 23686 depths are lower compared to the No Action Alternative. Lower lake levels in the summer
 23687 months under MO4 would change the quantity and quality of habitats in the Pend Oreille and
 23688 Farragut WMA lands. Increasing the area of exposed ground would temporarily increase
 23689 shorebird use of exposed mudflats, as well as shift the composition and distribution of wetland
 23690 vegetation as habitats stabilize after implementation. Without continued management of these
 23691 lands, it is highly likely that non-native, invasive plants would colonize exposed portions of the
 23692 lake shoreline over time, which reduces the overall structural and functional quality of these
 23693 habitats. The duration of these changes and time it takes for habitats to stabilize following
 23694 implementation would depend on the frequency and duration of consecutive dry years driving
 23695 lower lake levels.

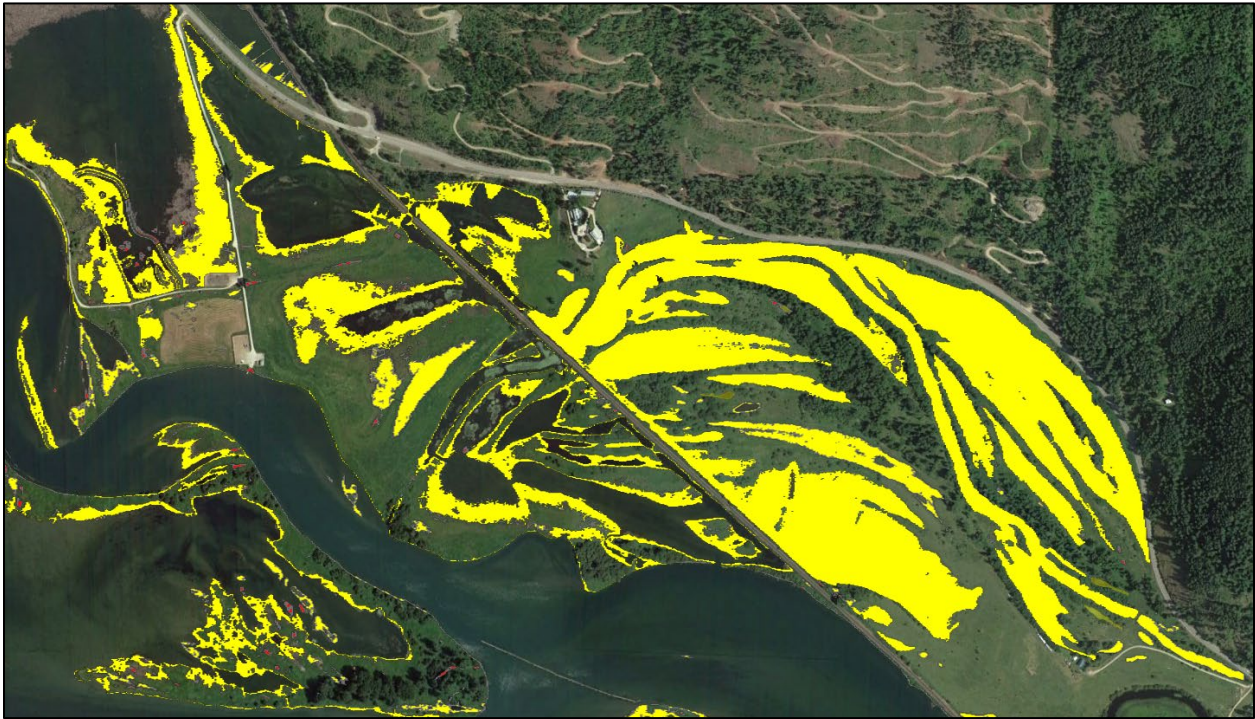


23696 **Figure 3-154. Shorelines of Denton Slough in Lake Pend Oreille Showing Average Land**
 23697 **Exposure for the No Action Alternative and MO4**

23698 Note: An additional 1,200 acres of exposed land would occur under MO4 in comparison with the No Action
 23699 Alternative (elevations highlighted in gray, yellow, and orange).
 23700

23701 The composition of vegetation in wetland habitats is expected to transition to species more
 23702 tolerant of dry or drought conditions or may become upland habitat types over time. These
 23703 changes would result in an overall decrease in the quantity, quality, and distribution of wetland

23704 habitats adjacent to the reservoir shorelines in the Hungry Horse study area. Wildlife
23705 populations would experience increased risk from predatory animals (i.e., wolf and mountain
23706 lion). In response to a loss of wetland habitats and associated vegetation around the reservoir,
23707 birds could be displaced from nesting or sheltering habitat in forested and scrub-shrub or
23708 emergent herbaceous wetland habitats and would likely experience increased competition in
23709 remnant wetland habitats, if not leaving the area altogether. Ultimately, they may die off for a
23710 lack of similar, unoccupied habitats.



23711
23712 **Figure 3-155. Wetlands within the Clark Fork Delta on Pend Orielle Lake**

23713 Wildlife dependent upon wetland habitats would disperse to other areas where suitable habitat
23714 exists. In these situations, wildlife would experience temporary displacement and increased
23715 competition for limited resources until the system reaches an equilibrium as habitat stabilizes
23716 following implementation. In other instances, wildlife may forego breeding or experience
23717 reduced productivity for several years until suitable breeding habitat is available. For example,
23718 lower pool elevations may force beaver and muskrat to relocate to different locations within
23719 the study area where sufficient material is available for the construction of lodges and forage
23720 material. Under lower lake levels, the quantity, quality, and distribution of wetland habitats
23721 would decrease, resulting in parallel declines in species entirely dependent upon these habitat
23722 for all or part of their life cycles, including amphibians and insects, which support the food web
23723 and serve as prey resources for other animals, including birds, bats, and fish.

23724 The structure and function of wetland habitats in Lake Pend Oreille could change under lower
23725 lake levels and thus alter the quality and availability of nest materials for western grebes. These
23726 changes would affect nest quality, which could subsequently increase the vulnerability of nests,
23727 eggs, and young birds to predators. If nests are constructed in emergent herbaceous wetlands

23728 and then float into the main part of the reservoir, they would experience increased exposure to
23729 motorized boat traffic. Denton Slough provides a safe harbor for nesting Western grebes
23730 because it is shallow (Hull 2019). Nests could be pulled into the main portion of the reservoir
23731 and therefore would experience higher mortality due to increased exposure to weather
23732 conditions, which would result in decreased reproductive success over time. Similarly, the
23733 reproductive success of ground-nesting waterfowl could decrease if the birds experience higher
23734 rates of mortality from predation and exposure, as nests are located farther from the shoreline
23735 in lower quality habitats. On the other hand, lower pool elevations would increase the area of
23736 barren zones and mudflats supporting breeding and migratory shorebirds that forage on
23737 benthic invertebrates in the mud.

23738 Implementing the *McNary Flow Target* measure would increase water surface elevations on the
23739 Pend Oreille River downstream of Albeni Falls during the summer in average and low water
23740 events. The increase in water surface elevations would range between 6 and 8.5 inches
23741 compared to the No Action Alternative, and the difference decreases further downstream (see
23742 Section 3.2, *Hydrology and Hydraulics*, for greater detail). Because these changes are within the
23743 natural range of variation in the river across different water events, the increased river levels
23744 are not expected to change the quantity, distribution, or composition of habitats along the river
23745 relative to the No Action Alternative. However, MO4 could make wetland habitat available
23746 more frequently due to more frequent inundation. Therefore, MO4 may result in higher quality
23747 breeding, feeding, and sheltering conditions during the growing season and improve wildlife
23748 habitats and populations downstream of Albeni Falls.

23749 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

23750 No structural measures would be implemented in Region B under MO4, and therefore, the
23751 proposed structural measures would not impact floodplains, wildlife habitats, or populations.
23752 As described in Chapter 2, MO4 includes implementing seven operational measures in Region
23753 B: *McNary Flow Target*; *Update System FRM Calculation*; *Planned Draft Rate at Grand Coulee*;
23754 *Grand Coulee Maintenance Operations*; *Winter System FRM Space*; *Lake Roosevelt Additional*
23755 *Water Supply*; and *Chief Joseph Dam Project Additional Water Supply*. Collectively, these
23756 measures would influence operations in Region B by supporting downstream FRM, decreasing
23757 draft rates, and increasing diversions for water supply and irrigation. Implementing the *Update*
23758 *System FRM Calculation* and *Grand Coulee Maintenance Operations* measures influence
23759 operation of Grand Coulee by increasing operational flexibility of the dam and improving
23760 capacity during ongoing operations and maintenance actions similar to MO1.

23761 Shallow backwater habitat would become intermittently dry as water surface elevations
23762 decrease, causing immotile amphibian eggs like those of the western toad to desiccate.
23763 Because of the lack of vegetation or other habitat cover in the barren zone, small mammals
23764 (i.e., mice, voles, and shrews) would experience increased rates of predation, as they would be
23765 more susceptible to predators foraging along the reservoir shoreline. Areas that establish as
23766 emergent herbaceous wetlands would provide increased protection for some animals, as well
23767 as increasing overall biodiversity and productivity along the reservoir.

23768 For floodplains, annual average probability of inundation is expected to remain unchanged
23769 from current conditions in Region B, with negligible effects.

23770 Grand Coulee would be operated to support FRM operations in the lower Columbia River by
23771 implementing the *Winter System FRM* measure and support fish passage conditions in the
23772 lower Snake and Columbia Rivers by implementing the *McNary Flow Target* measure. In the
23773 dryer 40 percent of water years, May through August water levels under MO4 could be 10 to 20
23774 feet lower than No Action Alternative due to the *McNary Flow Target* measure, and the Lake
23775 would not reach the full elevation of 1,290 feet NGVD29 in about half of all years. See Chapter
23776 3.2, Hydrology and Hydraulics, for more detailed discussion of Lake Roosevelt water level
23777 changes. As a result, MO4 would effectively expose a larger barren zone in the elevation range
23778 of 1,260 feet to 1,280 feet NGVD29, which is used to getting wet every years for most of the
23779 year but is now going to be inundated less frequently. This would decrease the quantity,
23780 quality, and distribution of emergent herbaceous and forested and scrub-shrub wetland
23781 habitats adjacent to the shoreline in low-lying, shallow areas. The typical growing season in the
23782 Grand Coulee study area is April through October. Since pool elevations would be lower during
23783 the majority of the growing season, wetland habitats would experience prolonged periods of
23784 dry conditions, which would result in a shift in plant composition to species more tolerant of
23785 dry or drought conditions, or wetland habitats would transition to upland habitat types.

23786 Lake Roosevelt has the potential to be a crossing or migration corridor for large mammals, peak
23787 active season for these species in this area is from May through September. Habitat around
23788 Lake Roosevelt is traditional winter range habitat for big game with winter peak use from
23789 November through April. During the peak active season for these terrestrial mammals, water
23790 surface elevation levels would be lower than existing conditions and the No Action Alternative.
23791 This would have a moderate effect on migration of these species.

23792 Implementing the *Lake Roosevelt Additional Water Supply* measure at Grand Coulee and the
23793 *Chief Joseph Dam Project Additional Water Supply* measure at Chief Joseph support increased
23794 diversion of water from Lake Roosevelt and the Columbia River for irrigation and municipal and
23795 industrial uses between April and November. The winter FRM and adjustments for McNary
23796 flows have the largest effects on water surface elevation levels in Lake Roosevelt, while the
23797 water supply measure affects changes in outflow. These combined changes are expected to
23798 contribute to reductions in pool elevations in Lake Roosevelt upstream of Grand Coulee and
23799 decreased water surface elevations in the Columbia River downstream from Chief Joseph. The
23800 typical growing season at Chief Joseph is similar to Grand Coulee but lasts until November.
23801 Water withdrawal for irrigation overlaps with the growing season for both project areas,
23802 further reducing the water available for habitats adjacent to the river and lake shorelines.
23803 Downstream of Chief Joseph, the change in water surface elevation is typically less than 3
23804 inches, and this amount is expected to be consistent with natural range of variation and is not
23805 measurably different than the No Action Alternative. As a result, changes in water surface
23806 elevations downstream of Chief Joseph would have negligible effect on wildlife habitat and
23807 populations within the Chief Joseph study area. Under MO4, there would be negligible effects

23808 to floodplains in Region B because changes in flood elevations would typically be less than 0.3
23809 feet.

23810 In regard to potential effects in Canada, the effects to vegetation and wildlife resources and
23811 their habitats under MO4 are expected to be similar to the effects described for the United
23812 States portion of Region B

23813 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
23814 **HARBOR DAMS**

23815 Structural measures are *Additional Powerhouse Surface Passage, Lower Granite Trap*
23816 *Modifications, Lower Snake Ladder Pumps, Bypass Screen Modifications for Lamprey, Lamprey*
23817 *Passage Ladder Modifications, and Spillway Weir Notch Inserts*. These structural measures are
23818 not expected to result in widespread effects to floodplains, wildlife habitats, or populations.

23819 MO4 includes operational measures at Lower Granite, Little Goose, Lower Monumental, and Ice
23820 Harbor. No operational changes would occur at Dworshak under MO4, and consequently, there
23821 would be no changes in reservoir levels or dam outflow that would affect wildlife habitats or
23822 populations along the Clearwater River upstream of the confluence with the Snake River.
23823 Operational measures for Region C include *Spill for Adult Steelhead, Spill to 125% TDG,*
23824 *Contingency Reserves in Fish Spill, Spring & Fall Transport, Drawdown to MOP, and Above 1%*
23825 *Turbine Operations*. Annual average probability of inundation is expected to remain unchanged
23826 from current conditions in Region C, with negligible effects on floodplains.

23827 Under MO4, the reservoir elevations at the four lower Snake River dams would have an
23828 adjusted minimum operation pool (MOP) operation from March 15 through August 15 due to
23829 the *Drawdown to MOP* measure. At all four projects, the seasonal MOP range is increased from
23830 a 1.0-foot range to a 1.5-foot range, each with a 0.5-foot increase in the upper end of the
23831 range. Annual average probability of inundation is expected to remain unchanged from current
23832 conditions in Region C, with negligible effects on floodplains.

23833 Overall, wetland habitats would be wetter for longer time periods under MO4 compared to the
23834 No Action Alternative. Given these changes in river levels on the Snake River, forested and
23835 scrub-shrub wetlands would experience increased inundation in low-lying areas during the
23836 majority of the growing season. Woody vegetation is inundated for prolonged periods or with
23837 increased frequency compared to the No Action Alternative; this vegetation would convert to
23838 emergent plant species more tolerant of wet conditions.

23839 Conversely, because pool elevations would be higher along the Snake River during the spring
23840 and summer months compared to the No Action Alternative, there may be an increased
23841 quantity, quality, and distribution of wetted areas and off-channel pools along the river
23842 shorelines. These wetted areas support breeding habitats for wetland-dependent amphibians,
23843 such as the western toad and northern leopard frog. Similar to potential increases in water
23844 surface elevation on the lower Flathead River, vegetation along the Snake River could benefit
23845 from slightly more water in the river throughout the growing season. The overall quantity and

23846 functional quality of forested and scrub-shrub and emergent herbaceous wetlands would
23847 increase as a result of a prolonged period of wetted conditions, yielding higher productivity
23848 compared to the No Action Alternative. In response, these habitats would provide higher
23849 quality breeding, feeding, and sheltering conditions for a suite of wildlife species. For example,
23850 wetted areas along the riverbanks provide habitat for amphibians to lay eggs, and maintaining
23851 wetted conditions through the summer provides adequate habitat for tadpoles to grow and
23852 develop before pools dry up and shrink later in the summer. While the potential increase in
23853 water depth is not substantial (less than 4 inches), it may be sufficient to provide additional
23854 habitat for these species.

23855 As a result, there would be some effects to wildlife populations using these habitats. For
23856 example, the overall quantity and quality of habitat for ground-nesting birds, such as harlequin
23857 duck that breed along well-concealed streambanks or on islands between Silcott Island and Ice
23858 Harbor, would decrease. Additionally, if some woody vegetation transitions to emergent
23859 vegetation over time, the amount of nesting habitat for birds such as veery or warblers that
23860 nest in wetland thickets may decrease. In these circumstances, birds may be forced to relocate
23861 to other areas where suitable nesting habitat is available, which could increase competition for
23862 limited resources.

23863 The *Spill to 125 percent TDG* measure would increase the proportion of juvenile fish migrating
23864 in river because fewer fish will be transported. For example, it is estimated that the proportion
23865 of juvenile Snake River steelhead transported would decrease from 38.5 percent under the No
23866 Action Alternative to 7.3 percent under MO4. More juvenile fish migrating in the Snake and
23867 Columbia rivers would mean increased prey availability for fish eating birds and mammals.

23868 **Region D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

23869 Structural measures associated with MO4 in Region D are *Additional Powerhouse Surface*
23870 *Passage, Improved Fish Passage Turbines, Lamprey Passage Structures, Lamprey Passage*
23871 *Ladder Modifications, and Spillway Weir Notch Inserts*. These structural measures are not
23872 expected to result in widespread effects to wildlife habitats or populations.

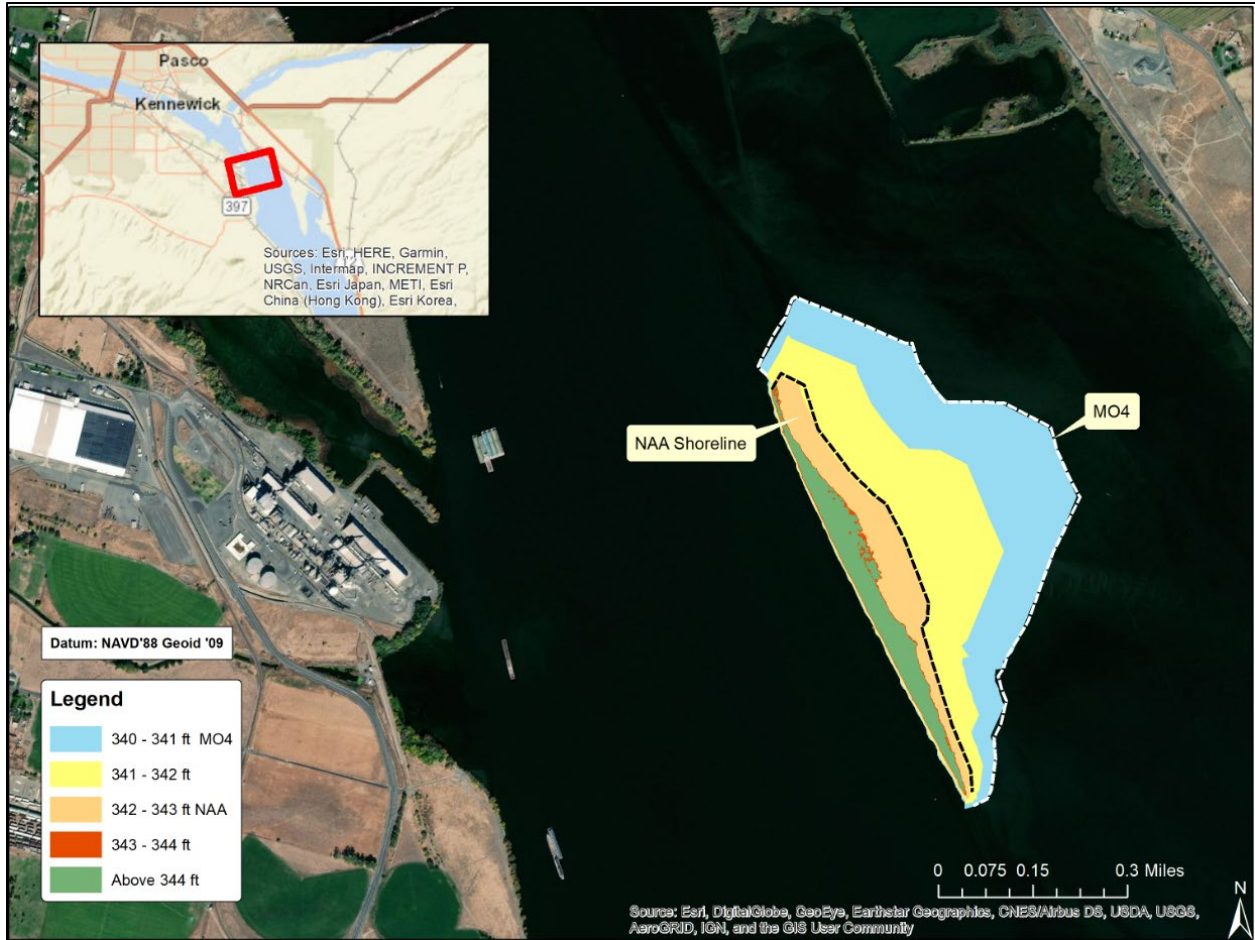
23873 Under MO4, there would be changes to the reservoir elevations at McNary, John Day, The
23874 Dalles, and Bonneville Dams. All would have an adjusted operating range because of the
23875 *Drawdown to MOP* measure, which results in a decreased operating range from March 25
23876 through August 15. McNary Dam would operate approximately 2 feet lower in operating range
23877 from the No Action Alternative. John Day Dam would operate approximately 1.5 to 2.5 feet
23878 lower than No Action Alternative. The Dalles Dam would operate 3.5 feet lower than the No
23879 Action Alternative. Bonneville Dam pool would operate 3.5 feet lower than the No Action
23880 Alternative.

23881 Operational measures associated with MO4 are *Spill for Adult Steelhead, Spill to 125% TDG,*
23882 *Contingency Reserves in Fish Spill, Drawdown to MOP, and Above 1% Turbine Operations*.
23883 Implementing the *Drawdown to MOP* measure would have effects on wildlife habitats and
23884 populations in Region D as a function of decreased pool elevations on the lower Columbia River

23885 above Bonneville Dam during the growing season. See Section 3.2, *Hydrology and Hydraulics*,
23886 for greater detail on changes to annual and monthly hydrology. There are no changes in pool
23887 elevations or river conditions outside of the growing season and, as a result, changes to wildlife
23888 habitats and populations would be the result of changes occurring during the growing season.
23889 Reductions in the annual average probability of inundation could cause minor to moderate
23890 effects on floodplains.

23891 Under these conditions, forested and scrub-shrub and emergent herbaceous wetland habitats
23892 would dry out, causing a widespread decrease in the quantity, quality, and distribution of these
23893 habitats in Region D. Additionally, the plant composition in wetland habitats would transition to
23894 upland plant species more tolerant of dry conditions, further reducing the availability and
23895 distribution of wetland habitats for wildlife on the lower Columbia River. There are several state
23896 and federal wildlife managed areas that could be impacted by this measure, including the
23897 McNary NWR, Umatilla NWR, Irrigon WMA, and Klickitat WMA. In addition to these locations,
23898 areas that are not managed specifically for wildlife but provide valuable habitat for a multitude
23899 of species would be impacted, including the Yakima River delta, Badger Island, the Walla Walla
23900 River delta upstream of McNary, the Umatilla IBA in Lake Umatilla, and Miller Rocks in Lake
23901 Celilo. Badger Island and Foundation Island would expand by 50 to 60 percent and 800 to 900
23902 percent, respectively, under MO4, beyond No Action Alternative conditions. These areas would
23903 expand the area of potential wetland habitats or become exposed mudflats (Figure 3-156). At
23904 Umatilla NWR, wetlands or exposed mudflats would expand by as much as 130 to 140 percent.

23905 Under MO4, portions of the shoreline that are inundated under the No Action Alternative
23906 would be exposed during the growing season, and shallow open water habitats would
23907 transition to exposed mudflats. As invertebrate communities become established in the years
23908 following implementation, these areas would attract wading birds, such as herons and egrets,
23909 as well as shorebirds that forage on the exposed sediments. In addition to increasing the
23910 quantity and distribution of exposed shorelines for foraging habitat, the exposed sediments
23911 would increase the quantity and distribution of nesting habitats for ground-nesting colonial
23912 waterbirds, including Caspian tern, double-crested cormorant, gulls, and pelicans. Region D
23913 includes notable breeding colonies of these birds at several locations, and implementing MO4
23914 would increase the availability of suitable habitat for these birds, which would support
23915 increased population growth if food resources were available to support nesting birds and
23916 fledglings. At Blalock Islands, the relative proportion of habitat available to nesting waterbirds
23917 under MO4 would increase by 120 percent and expand to approximately 8.0 acres compared to
23918 the amount available under the No Action Alternative, which is approximately 3.6 acres. In
23919 1976, Asherin and Claar found that decreased water surface elevations in the McNary pool
23920 exposed land bridges to Badger and Foundation islands—as well as three of the five Hat
23921 Islands—and coyote predated goose nesting on these islands (Asherin and Claar 1976).
23922 Conversely, if the islands were effectively isolated from the mainland and terrestrial predators,
23923 island habitat would be more suitable for nesting waterfowl.



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Figure 3-156. Foundation Island in McNary Pool

Note: The island would expand by 800 to 900 percent under MO4. The island (highlighted in green, red, and orange) would expand to areas highlighted in yellow and blue. The legend units are feet NAVD88.

23928 Following implementation of MO4 and lower water levels in the reservoirs, wetland habitats
23929 upstream of Bonneville Dam could transition to upland habitat types over time as the
23930 composition of plants shifts to species more tolerant of drier conditions. Given the extent of
23931 rocky shorelines throughout the lower Columbia River, there is limited potential for wetlands to
23932 establish at lower elevations. Therefore, forested and scrub-shrub and emergent herbaceous
23933 wetlands and off-channel habitats could convert to drier habitat types, decreasing the overall
23934 quantity, quality, and distribution of regionally important wetlands in upper reaches of Region
23935 D. Wetland function would decrease, and overall productivity of these habitats would
23936 subsequently decrease, resulting in widespread effects on the availability of food resources for
23937 resident and migratory wildlife. The McNary and Umatilla NWRs and Umatilla IBA provide
23938 critical wintering habitat for tens of thousands of ducks and geese in the Pacific Flyway.
23939 Decreasing the quantity and quality of these important wetland habitats would have substantial
23940 effects on these birds by causing them to relocate to more favorable overwintering habitat, and
23941 potentially reducing population fitness and decreasing survival of young birds and females for
23942 overwintering birds that continue to overwinter in these two refuges.

23943 Changes to the quantity, quality, and distribution of wetland habitats in upper portions of
23944 Region D would also impact amphibians, migratory songbirds, and mammals. Western toads
23945 and northern leopard frogs breed in pools and slow-moving waters. If wetland habitats
23946 desiccate and shrink in response to the *Drawdown to MOP* measure, a lack of breeding pools
23947 and wetted conditions would be detrimental to the survival of amphibian egg masses and
23948 tadpoles. Similar to the potential effects to waterfowl, decreasing survival of amphibians in
23949 these areas would influence overall productivity of the population, and where populations are
23950 declining, these trends would continue or increase. Furthermore, as woody vegetation changes
23951 under drier conditions or becomes stressed under prolonged periods of drought, the suitability
23952 or quality of breeding habitats would decrease and increase competition for habitat where it
23953 occurs. Fawning habitat would decrease if the quality of wetland habitats decreases to the
23954 point that insufficient cover and shelter is available for juvenile deer to hide in while adults
23955 forage nearby. If tree cover decreases because river conditions no longer support wetland-
23956 dependent vegetation, nesting habitats for woodpeckers, raptors such as eagles, falcons and
23957 hawks, and migratory songbirds would decrease. As a result, birds would be displaced to areas
23958 with suitable habitats, increasing competition for limited resources.

23959 Actions currently implemented under the No Action Alternative that are expected to continue
23960 under MO4 include efforts to reduce the spread and establishment of invasive species
23961 throughout Region D. Decreasing pool elevations between McNary and Bonneville Dams in
23962 response to the *Drawdown to MOP* measure could result in a widespread increase in the
23963 distribution and establishment of invasive species as they spread into areas where they do not
23964 occur under the No Action Alternative. As a result, the overall distribution and quantity of
23965 invasive species in Region D could increase under MO4, which would reduce habitat quality for
23966 a suite of wildlife. Where no management efforts are implemented, invasive species are
23967 expected to persist under MO4, similar to the No Action Alternative.

23968 Reductions in the annual average probability of inundation could cause minor to moderate
23969 effects on floodplains. Minor reductions in flood elevations would occur below Bonneville Dam
23970 for floods that occur with moderate frequency, which could have minor effects on floodplain
23971 benefits in this region. On average, changes in river levels downstream of Bonneville Dam
23972 would be less than 3 inches and within the natural range of variability in daily water levels. For
23973 this reason, MO4 is not expected to cause measurable effects to wildlife populations or their
23974 habitats downstream of Bonneville Dam. The lower portions of the Columbia River would
23975 continue to support valuable habitat for fish and wildlife, and current trends are expected to
23976 continue.

23977 Decreasing pool elevations under the *Drawdown to MOP* measure increases survival of juvenile
23978 salmonids by decreasing downstream travel times. Refer to Chapter 3.5 for specific effects on
23979 anadromous fish species. Furthermore, the *Spill to 125 Percent TDG* measure results in fewer
23980 juvenile salmon and steelhead collected and transported to downstream of Bonneville Dam. As
23981 such, this measure effectively provides an increase in prey resources between the confluence of
23982 Snake and Columbia Rivers and Bonneville Dam. Fish are also anticipated to move through the

23983 system faster as a result of these measures, which may increase their ocean survival and adult
23984 fish return rates.

23985 **FLOODPLAINS**

23986 Under MO4, changes in flood elevations would typically be negligible (absolute value less than
23987 0.3 feet) across the Columbia River Basin for all flood frequencies, from regularly occurring
23988 floods (AEP of 50 percent) to the base flood (AEP of 1 percent). Moderate decreases in flood
23989 elevations (absolute value less than 1.5 feet) are predicted in Region D for Bonneville Reservoir,
23990 and minor reductions in flood elevations (absolute value less than 1 foot) are predicted in
23991 Region D for the upper part of Lake Celilo Reservoir (for floods with AEP values from 50 to 2
23992 percent) and for the Columbia River below Bonneville Dam for floods with moderate
23993 frequencies (AEP values from 15 to 5 percent). Based on these results, the annual average
23994 probability of inundation would remain unchanged from current conditions in most of the
23995 basin, with minor reductions in inundation frequency in the lower Columbia River below John
23996 Day Dam. These changes could have minor effects on floodplain benefits in the affected
23997 regions.

23998 **SPECIAL STATUS SPECIES**

23999 This section discusses the potential effects of implementing MO4 on ESA-listed plant and
24000 animal species that may occur in the study area.

24001 Table 3-107 provides details about ESA-listed wildlife species that are known or likely to occur
24002 in the study area and the potential effects to these species or their critical habitats in response
24003 to MO4 implementation. Similar to the No Action Alternative, it is assumed that those species
24004 listed under the Endangered Species Act and present in the study area will remain listed, and
24005 existing regulatory and best management practices would reduce the likelihood that
24006 populations would continue declining or become extinct. It is assumed that neither grizzly bear
24007 critical habitat nor whitebark pine would be listed, and their presence and population in, or in
24008 the vicinity of, the study area would remain relatively stable.

24009 According to the modeling conducted for fish survival and passage in Section 3.5, the CSS model
24010 predicts a major increase in adult returns, while National Marine Fisheries Service predicts a
24011 decrease in adult returns. Therefore, numbers of returning salmon runs are uncertain and could
24012 increase or decrease as a result of MO4. These return rates mean that effects to marine
24013 mammals, such as sea lion and Southern Resident killer whale, are also uncertain. There may be
24014 a negligible benefit or negligible detriment to these species. Consequently, MO4 would not
24015 cause a decrease or increase in the population of Southern Resident killer whale, California sea
24016 lion, or Steller sea lion.

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Table 3-107. Sensitive Species Effects for MO4

Common Name	Scientific Name	Status of Species and Critical habitat	Projects Where Species Occurs	Effects of MO4
Mammals				
Grizzly bear	<i>Ursus arctos horribilis</i>	ESA status: T CH: Proposed	Libby Hungry Horse	Construction of structures on the dams: No effect. Bears are spatially removed from dams. Hydrology: Negligible effect. Hydrograph would be beneficial to establishment of cottonwood seedlings. Benefit to riparian species. Conclusion: Negligible effect. MO4 would have a negligible benefit to the grizzly bear from NAA conditions. MO4 is not likely to adversely affect the grizzly bear.
Columbian white-tailed deer	<i>Odocoileus virginianus leucurus</i>	ESA status: T CH: None	Downstream of Bonneville Dam	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Virtually no change in water surface elevation within range of Columbian white-tailed deer. No change is suitable habitat or probability of flooding individuals. Conclusion: Negligible effect to Columbian white-tailed deer from MO4. MO4 is not likely to adversely affect the Columbian white-tailed deer.
California sea lion	<i>Zalophus californianus</i>	ESA status: None CH: None Marine Mammal Protection Act	Downstream of Bonneville Dam, occasionally seen at The Dalles Dam	Construction of structures on dams: Negligible, temporary effect. Minimal visual and noise disturbance, potentially resulting in avoidance of the area. Prey availability: Negligible effect. Fish models predict a negligible increase or decrease in available prey. Conclusion: Negligible effect. Numbers of California sea lions that feed at Bonneville Dam would remain similar to NAA conditions. Hazing would be similar to NAA. Overall, the population of California sea lions would remain stable.
Steller sea lion	<i>Eumetopias jubatus</i>	ESA status: None CH: None Marine Mammal Protection Act	Downstream of Bonneville Dam	Construction of structures on dams: Temporary. Negligible effect. Minimal visual and noise disturbance, potentially resulting in avoidance of the area. Prey availability: Negligible effect. Fish models predict a negligible increase or decrease in available prey. Conclusion: Negligible effect. Numbers of Steller sea lions at Bonneville Dam remain similar to NAA conditions. Hazing would be similar to NAA. Overall, the population of Steller sea lions would remain stable.
Southern Resident killer whale Distinct Population Segment	<i>Orcinus orca</i>	ESA status: E CH: None	None	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat for Southern Resident killer whale, no individuals or habitat affected. Prey Availability: Negligible effect. The Snake River spring/summer Chinook salmon is a negligible portion of their overall diet. Fish models predict that lower Snake River Chinook salmon smolt-to-adult returns would be slightly more or less than NAA. Fish hatcheries would continue similar to NAA. This overall effect could change Southern Resident killer whale distinct population segment behavior as whales react to the changes in prey availability. Conclusion: Negligible effect. Southern Resident killer whale would have similar available prey base compared to NAA conditions. MO4 would not adversely affect the Southern Resident killer whale distinct population segment.
Birds				
Yellow-billed cuckoo	<i>Coccyzus americanus</i>	ESA status: T CH: Proposed	Study area is within the range of yellow- billed cuckoo.	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. MO4 is unlikely to have any effect on yellow-billed cuckoo due to infrequent sightings of the birds near the study area. However, MO4 operations, unlike current operations, would result in reduced winter flows allowing for establishment of cottonwoods galleries within the active floodplain. MO4 operations have the potential to reverse trends of reduced riparian habitat. Long-term effects of increased riparian vegetation along the Kootenai River (<i>Winter Stage for Riparian</i> measure) may equate to increased acreages of suitable habitat for the western yellow-billed cuckoo. Conclusion: Negligible improvement. There would be some overall benefit at the Libby area for cottonwood recruitment. Overall, cottonwoods may continue to decline in areas where they are established. MO4 is not likely to adversely affect the yellow-billed cuckoo.
Bald eagle and golden eagle	<i>Haliaeetus leucocephalus</i> <i>Aquila chrysaetos</i>	Bald and Golden Eagle Protection Act	Throughout the study area.	Construction of structures on the dams: No effect. Hydrology: Negligible effect. MO4 operations would reverse trends in reducing riparian habitat along the Kootenai River. With improved riparian function, bald eagles could nest in mature cottonwood trees. Overall, cottonwoods could continue to decline in areas where they are established. Conclusion: Negligible effect. Forested areas should remain forested along the riparian system. Therefore, the effect to bald and golden eagles should be negligible in compared to NAA. MO4 is not likely to adversely affect the bald or golden eagle populations.
Streaked horned lark	<i>Eremophila alpestris strigata</i>	ESA status: T CH: Designated	Downstream of Bonneville Dam	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: No effect. Virtually no change in water surface elevation below RM 123. Not likely to convert suitable habitat or flood individuals. Conclusion: No effect. MO4 is not likely to adversely affect the streaked horned lark.

Common Name	Scientific Name	Status of Species and Critical habitat	Projects Where Species Occurs	Effects of MO4
Plants				
Ute ladies'-tresses	<i>Spiranthes diluvialis</i>	ESA status: T CH: None	Grand Coulee Chief Joseph	<p>Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected.</p> <p>Hydrology: Negligible Effect. Changes in water surface elevations could alter regions along the water margins where the plant occurs. The general trend toward lower water surface elevations throughout most of the year due to the large deviation at Grand Coulee would have a negative effect on the plant, if the plant were to grow along the banks and margins of Lake Roosevelt.</p> <p>Conclusion: Negligible effect. There would be low effect to this species if the plant were to grow along the banks and margins of Lake Roosevelt. MO4 is not likely to adversely affect Ute ladies'-tresses.</p>

24020 Note: C = Candidate for listing; CH = Designated Critical Habitat; E = Endangered; T = Threatened.

24021 **SUMMARY OF EFFECTS**

24022 Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue,
24023 including protection, mitigation, and enhancement of wildlife habitat as discussed in Section
24024 5.2.1. The effect of MO4 could be summarized by region, as follows.

24025 In Region A, under MO4, changes to available wildlife habitat, wetlands, and vegetation would
24026 occur in Lake Kootenai and the Kootenai River. The average annual drop in surface water
24027 elevations in the Kootenai River would alter wetland types along the riverbanks and riparian
24028 areas. These fluctuations would inundate narrow bands of emergent vegetation and wetlands
24029 along the Kootenai River shoreline during the growing season and could result in a minor
24030 change on wildlife usage. In Lake Kootenai, the quantity of barren area around the lake would
24031 decrease under MO4, allowing for more potential vegetation establishment around the margins
24032 of the lake which would have a minor beneficial effect on wildlife that access the lake.

24033 Further, MO4 would alter Hungry Horse water surface elevations and outflows and the
24034 subsequent effects on vegetation and habitat. The decrease in the number of days when the
24035 reservoir is full during the growing season would result in drier conditions for wetlands and
24036 riparian vegetation around the reservoir. These changes would result in an overall decrease in
24037 the quantity, quality, and distribution of wetland habitats for certain wildlife in the narrow band
24038 of vegetation adjacent to the reservoir shorelines. In the drier 50 percent of years, MO4 would
24039 expose mudflats and barren lands that are typically covered by water during summer in Lake
24040 Pend Oreille under the No Action Alternative. Overall, for Region A, there would be a moderate
24041 effect on wetlands, vegetation, habitat, and wildlife under MO4, although the annual average
24042 probability of inundation is predicted to remain unchanged from current conditions.

24043 In Region B, pool elevations in Lake Roosevelt would be lower during the winter, spring, and
24044 summer months. Because pool elevations would be lower during the majority of the growing
24045 season, wetland habitats would experience prolonged periods of dry conditions, which would
24046 result in a shift in plant composition to species more tolerant of dry or drought conditions, or
24047 wetland habitats would transition to upland habitat types. MO4 would effectively increase the
24048 barren zone around the lake and change patterns of inundation to the extent that emergent
24049 wetland and scrub-shrub wetlands would be reduced. These changes are anticipated to have
24050 minor adverse effects on quantity or distribution of wildlife habitat. Implementing the *Planned*
24051 *Draft Rate at Grand Coulee* measure would decrease sloughing or landslides in the winter and
24052 early part of the growing season. Changes in water surface elevations downstream of Chief
24053 Joseph Dam would have negligible effects on wildlife habitat and populations within the Chief
24054 Joseph study area. Annual average probability of inundation would remain unchanged from
24055 current conditions in Region B. Overall, for Region B, there would be a minor adverse effect on
24056 wetlands, vegetation, habitat, and wildlife under MO4.

24057 In Region C, river and pool elevations would be higher along the Snake River during the spring
24058 and summer months compared to the No Action Alternative, there may be an increased
24059 quantity, quality, and distribution of wetted areas and off-channel pools along the river
24060 shorelines. These wetted areas support breeding habitats for wetland-dependent wildlife

24061 species. Overall, for Region C, there would be a negligible effect on floodplains, wetlands,
24062 vegetation, habitat, and wildlife under MO 4.

24063 In Region D, implementing the *Drawdown to MOP* measure would have effects on wildlife
24064 habitats and populations as a function of decreased pool elevations on the lower Columbia
24065 River above Bonneville Dam during the growing season. Moderate decreases in elevations
24066 would occur in Bonneville Reservoir, with minor reductions for the upper part of Lake Celilo
24067 Reservoir. Under these conditions, forested and scrub-shrub and emergent herbaceous
24068 wetland habitats could dry out, causing a widespread decrease in the quantity, quality, and
24069 distribution of these habitats in Region D. Additionally, the plant composition in wetland
24070 habitats would transition to upland plant species more tolerant of dry conditions, further
24071 reducing the availability and distribution of wetland habitats for wildlife on the lower Columbia
24072 River. Associated with this transition, MO4 could increase the availability of suitable habitat for
24073 ground nesting birds, which could support increased population growth if food resources are
24074 available. Overall, for Region D, there would be minor impacts to floodplains below John Day
24075 Dam, and a moderate effect on wetlands, vegetation, habitat, and wildlife under MO4.

24076 For special status species in all regions, multiple special status species would be impacted by
24077 MO4 beyond No Action Alternative conditions. Grizzly bear may slightly benefit from an
24078 enhanced riparian system downstream of Libby Dam. Riparian vegetation may produce more
24079 berries, a food source for grizzly bear. Columbian white-tailed deer may experience a negligible
24080 effect from MO3. California sea lion and Steller sea lion may experience a negative effect
24081 because of temporary construction activities at Bonneville Dam. However, this effect should be
24082 temporary and negligible. Yellow-billed cuckoo habitat may be slightly affected by changes in
24083 hydrology. This effect is considered negligible. Bald eagle habitat may be slightly affected by
24084 changes in hydrology. This effect is considered negligible. Ute ladies'-tresses may be slightly
24085 affected by changes in hydrology. This effect is considered negligible. Overall, there would be a
24086 low impact on most special status species.

24087 **3.6.4 Tribal Interests**

24088 Plants and animals are important to tribes throughout the Columbia River Basin. They are used
24089 for subsistence, ceremonies, medicines, art, clothes, and items of everyday use. They play
24090 fundamental roles in diet, materials, and spiritual practices. Tribal traditional ecological
24091 knowledge relies upon a holistic perspective of humans, ecosystems, economies, and cultures
24092 for the use of plants and animals.

24093 Changing hydrology can impact vegetation, plant communities, and wildlife. The primary effects
24094 to vegetation, wetlands, floodplains, and wildlife, as described above in Section 3.6.3 under the
24095 action alternatives, relate to changing water surface elevations below projects and changing
24096 reservoir levels that result in more frequent or extensive exposure of the barren area
24097 surrounding storage reservoirs. In Regions A and B, changes to water surface elevations may
24098 cause wetland habitats to shift slightly, or they may convert to drier habitat types. Wetlands
24099 may shift up or down, and increase or decrease in size, depending on location and water levels.
24100 Individual plants that are important for traditional uses, such as cottonwood, wapato, or tule,

24101 may be lost in isolated areas or their range may expand—it depends on the plant, location,
24102 depth of water, changes in hydrology, soil moisture, and other growing conditions. Any loss or
24103 changes, however, would not result in population level effects or benefits because: the effects
24104 would be isolated to a narrow band adjacent to rivers and reservoirs; the impacted areas are
24105 generally small relative to the overall watersheds or reaches they are located in; and there are
24106 seed or root sources available for re-colonization if individuals are lost. Furthermore, changes in
24107 habitats may benefit some traditional-use plants.

24108 The biggest change to vegetation and wetlands would come under MO3 along the Snake River
24109 from Lower Granite Dam to McNary Dam because of dam breaching. There would be
24110 substantial changes in plant communities at least for the short term (up to 10 years) depending
24111 on successful mitigation. After dam breach, newly exposed streambanks, and benches would be
24112 devoid of vegetation. Existing wetland habitat would convert to drier vegetation types, and
24113 there would be increased potential for exposed areas to be colonized by invasive species.
24114 Willow communities currently along the riverbanks would likely be perched, may lose
24115 connectivity with groundwater, and could die in the short term. Plant communities along this
24116 long reach of the Snake River may shift to those more tolerant of dry conditions that can do
24117 with less soil moisture. Traditional-use plants that are emergent wetland species would be lost
24118 in areas impacted by dam breaching, unless they are part of the replanting effort. However, like
24119 in Regions A and B, these areas would be isolated, and other locations outside the floodplain
24120 would not be impacted. Mitigation proposed under MO3 includes measures to replant the area
24121 with appropriate species for soil conditions. Mitigation would ameliorate the effects described
24122 above to an extent, and areas would benefit greatly by replanting and would shorten the
24123 timeframe for adverse effects to less than 60 years.

24124 **3.7 POWER GENERATION AND TRANSMISSION**

24125 **3.7.1 Introduction and Background**

24126 Bonneville is a Federal power marketing administration designated by statute to sell power and
24127 transmission services throughout the Pacific Northwest region. Bonneville sells electric power
24128 from CRS projects, operated and maintained by the Corps and Reclamation, to its regional firm
24129 power customers across the Pacific Northwest, including municipalities, public utility districts
24130 (PUDs), cooperatives, Federal agencies, direct service industries (DSIs), and investor-owned
24131 utilities (IOUs). These wholesale power customers either use the power directly or resell
24132 electricity to residential, commercial, and industrial retail customers (i.e., “end users”).

24133 Bonneville also operates and maintains about 15,000 circuit miles of the high-voltage
24134 transmission system within the Pacific Northwest region (Bonneville 2018a). This system
24135 integrates and transmits electric power within the Pacific Northwest region and interconnects
24136 with external transmission systems throughout the western United States and parts of Canada
24137 and Mexico. Separate from its power sales, Bonneville sells transmission services (for the
24138 delivery of electricity from generating resources to end users) and associated ancillary services
24139 (for maintaining transmission system reliability) to regional firm power customers, independent
24140 power producers, and power marketers.

24141 The MOs have the potential to affect the availability of power to meet regional demand, as well
24142 as the flow of power across the transmission system. Together, these changes could affect costs
24143 for both power and transmission services, wholesale and retail rates, and, ultimately, regional
24144 and local economies.

24145 **3.7.1.1 Statutory Framework**

24146 Bonneville was created by Congress through enactment of the Bonneville Project Act in 1937,
24147 Pub. L. No. 75-329, 50 Stat. 731 (codified as amended at 16 U.S.C. §§ 832-832m (2012)) to
24148 market and transmit electric power produced by Federal hydropower dams in the Pacific
24149 Northwest. Bonneville’s authority to market power generated from the entire Federal Columbia
24150 River Power System¹ (FCRPS), of which the Columbia River System hydropower dams are a
24151 subset, is codified in Section 8 of the Federal Columbia River Transmission System Act of 1974,
24152 Pub. 93-454, 88 Stat. 1376, (codified as amended at 16 USC §§ 838-838l (2012)). The Federal
24153 Columbia River Transmission System Act also gave Bonneville express authority to operate and
24154 maintain the Federal Transmission System within the Pacific Northwest and to construct
24155 improvements, betterments, and additions to and replacements of the system. The terms and
24156 rates upon which Bonneville may sell power and transmission services are subject to several
24157 statutes, including the Bonneville Project Act, the Flood Control Act of 1944, Pub. L. No. 78-534,
24158 58 Stat. 887 (codified at 16 U.S.C. § 825s (2012)), the Federal Pacific Northwest Consumer
24159 Power Preference Act of 1964, Pub. L. No. 88-552, 78 Stat. 756 (codified at 16 U.S.C. §§ 837-

¹ The FCRPS consists of the federal transmission system and 31 federally-owned dams on the Columbia River and its tributaries.

24160 837h (2012)), the Federal Columbia River System Transmission Act of 1974, and the Pacific
24161 Northwest Electric Power Planning and Conservation Act, 1980, Pub. L. No. 96-501, 94 Stat.
24162 2697 (codified at 16 U.S.C. § 839-839h (2012)).

24163 **3.7.1.2 Historical Context**

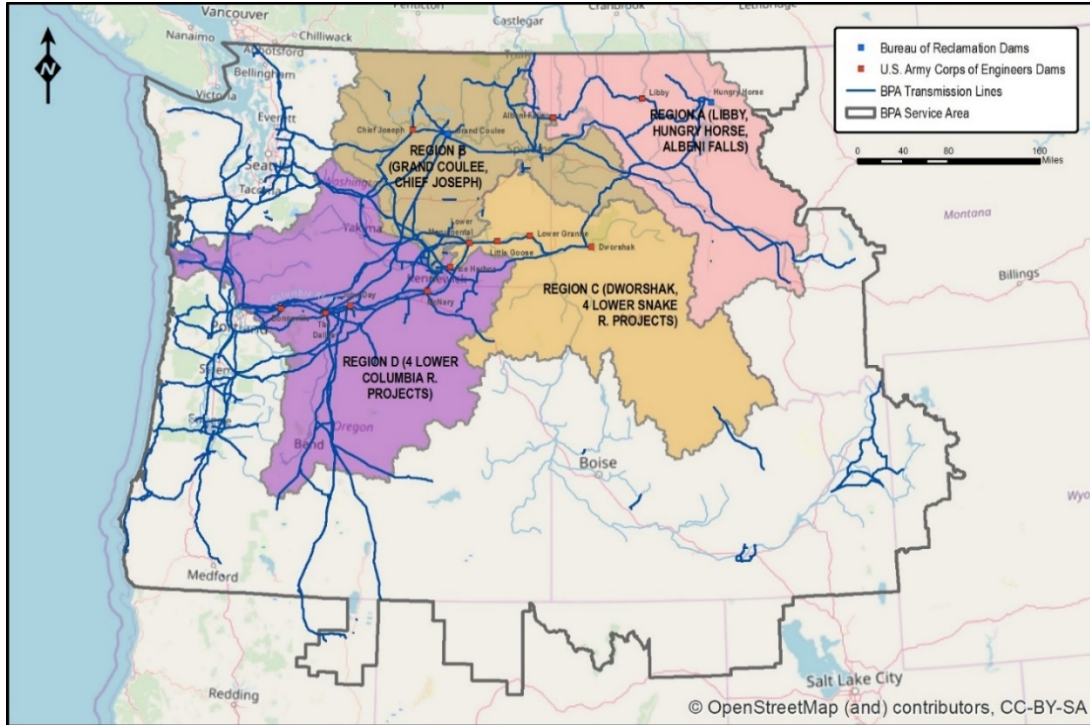
24164 Beginning in 1937, Bonneville first marketed the power from the Bonneville dam and began the
24165 construction of transmission systems to extend delivery of Federal power to purchasers
24166 throughout the Pacific Northwest. With the addition of each Federal dam, hydroelectric power
24167 from Federal projects could be generated at very low costs compared to other power
24168 resources, such as IOU's resources. The Bonneville Project Act's rate directives allowed for the
24169 setting of uniform rates to extend the benefits of the low-cost Federal power system as widely
24170 as possible, including remote, rural communities. The uniform rates are also known as "postage
24171 stamp rates," in references to the concept that postage stamps ensure mail delivery across the
24172 street or across the nation at a posted uniform rate. As such, Bonneville broadened the reach of
24173 Federal power by constructing transmission to deliver Federal power to sparsely populated and
24174 rural areas. In turn, PUDs and rural electric cooperatives were encouraged to form and request
24175 Federal power from Bonneville to serve their customer base.

24176 **3.7.1.3 Area of Analysis**

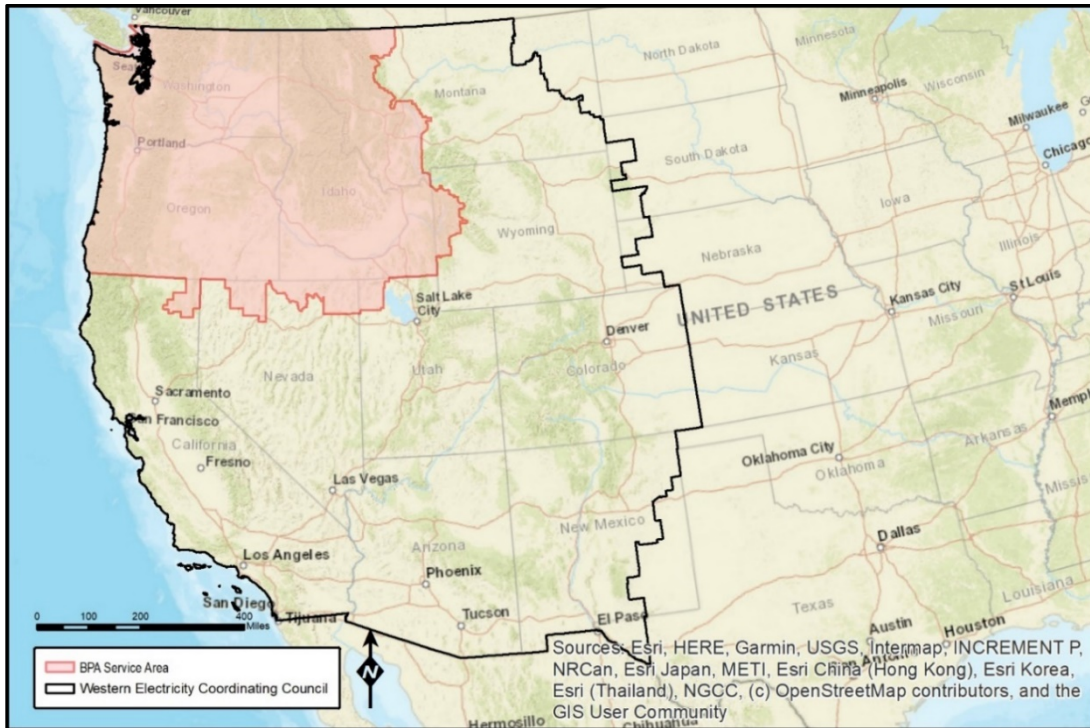
24177 The areas of analysis for the power and transmission resources are different because of the
24178 nature of the services and products. Both the power and transmission analyses are focused on
24179 the Bonneville service area shown in Figure 3-157 and are not split into the four CRSO analysis
24180 regions used in the EIS given the interrelated nature of the systems across these regions.
24181 Bonneville's service area is defined by the Northwest Power Act as the Pacific Northwest, which
24182 includes Oregon, Washington, Idaho, the portion of Montana west of the Continental Divide,
24183 and the portions of Nevada, Utah, northern California, and Wyoming within the Columbia River
24184 drainage basin ("Bonneville's Service Area").² However, because Bonneville regularly markets
24185 its surplus power both within and outside the Pacific Northwest, the power analysis additionally
24186 considers potential effects on the power markets within the larger Western Interconnection
24187 area (Figure 3-158).

24188 For additional discussion on potential effects to areas outside of the Pacific Northwest, see
24189 Section 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*.

² 16 U.S.C. § 839a(14) (2018).



24190
 24191 **Figure 3-157. Transmission Area of Analysis – the Bonneville Service Area and Transmission**
 24192 **Lines**
 24193 Source: Bonneville (2018a)



24194
 24195 **Figure 3-158. Power Area of Analysis – the U.S. Portion of the Western Interconnection and**
 24196 **the Bonneville Service Area**
 24197 Source: Bonneville (2018a); WECC (2018a)

24198 **3.7.2 Affected Environment**

24199 Sections 3.7.2.1 through 3.7.2.3 describe the power and transmission systems, focusing on
24200 those elements that could be affected by the MOs. Section 3.7.2.4 describes the coordination
24201 of the two systems. Sections 3.7.2.5 through 3.7.2.10 provide an overview of the Pacific
24202 Northwest electric power market in which Bonneville competes, and the factors influencing the
24203 rates that Bonneville charges its firm power customers. Section 3.7.2.11 describes the retail
24204 electricity market and provides an overview of the regional retail rates paid by end users.

24205 **3.7.2.1 Power Generation**

24206 Bonneville sells firm power at wholesale under long-term contracts to 136 power customers
24207 within a 300,000-square-mile service area in the Pacific Northwest. The Bonneville service area
24208 is geographically located within the boundary of the Western Interconnection power system.
24209 The Western Interconnection is one of four major North American power systems and includes
24210 power generation and transmission facilities across 14 U.S. states, 2 Canadian provinces, and
24211 parts of Mexico (WECC 2018a). Bonneville imports power and exports surplus power (i.e.,
24212 power not needed to meet Bonneville’s firm power commitments) beyond the Pacific
24213 Northwest within the Western Interconnection.

24214 Table 3-108 provides a comparison of the power-generating capacity within the Western
24215 Interconnection, the Pacific Northwest region, and CRS projects. It is important to recognize
24216 that “capacity” is distinct from “energy,” and that the MOs have the potential to affect them in
24217 different ways. Capacity is defined as the maximum potential output of a generation unit that
24218 can be physically produced at any given instant and is commonly expressed in megawatts
24219 (MW). Generators are not operated at full capacity at all times, and output can vary according
24220 to a variety of factors such as lower demand, market conditions, and variability in fuel sources.
24221 In this context, energy is defined as the amount of electricity generated at a project or power
24222 plant over a period of time and is expressed in megawatt-hours (MWh) or average megawatts
24223 (aMW). An aMW is a unit of energy representing 1 MW of electric power capacity generated
24224 continuously over a year. One aMW is equal to 8,760 MWh. Both capacity and energy
24225 generation trends are presented in the discussion below.

- 24226 • **Western Interconnection Resources:** The diverse mix of generation resources, referred to
24227 as a “resource mix,” in the Western Interconnection constitutes roughly 20 percent of all
24228 national power generation, with approximately 40 percent of all national hydropower
24229 capacity and 35 percent of all wind and solar capacity. Given the geographic, climatic, and
24230 consumer (e.g., urban and rural, residential, commercial, and industrial electricity end
24231 users) diversity across the Western Interconnection, demand for and generation of power
24232 varies greatly. Coordination across the Western Interconnection allows for planning across
24233 this diverse geography to ensure cost-effective and reliable power. Overall, across the
24234 Western Interconnection for 2016, there were 94,863 aMW generated, of which
24235 hydropower generated roughly 26,000 aMW (WECC 2018a).

- 24236 • **Pacific Northwest Regional Resources:** The Pacific Northwest regional resources are a
24237 component of the Western Interconnection resources. Table 3-108 illustrates the
24238 predominance of hydropower capacity (54 percent) in the resource mix of the Pacific
24239 Northwest region. Figure 3-159 provides a geographic overview of generating resources in
24240 the Pacific Northwest region (NW Council 2018a). There is the potential for non-Federal
24241 hydroelectric projects downstream of CRS projects to be affected by the MOs. These
24242 projects are highlighted in purple in Figure 3-159, and their generation characteristics are
24243 described in Table 3-109. These projects have capacity ranging from 90 to 1,299 MW. For
24244 further information, including a list of all projects downstream of the CRS projects, see
24245 Section 1.9.3, *Non-Federal Dams and Reservoirs*.

24246 **Table 3-108. Power Generation Capacity in Megawatts (current as of 2018)**

Type	Western Interconnection	Pacific Northwest Region	Bonneville ^{1/}	Columbia River System Projects
Hydropower	72,000	34,318	22,441 ^{2/}	21,540
Wind	23,000	9,213	248	0
Natural Gas	102,000	9,452	0	0
Coal	37,000	7,146	0	0
Solar	16,000	431	0	0
Nuclear	8,000	1,144	1,144	0
Geothermal	3,000	61	0	0
Other	9,000	2,184	0	0
Total Capacity	267,000 MW	63,457 MW	23,833 MW	21,540 MW

24247 Note: The estimates across geographic regions are not additive; the Pacific Northwest is geographically within the
24248 Western Interconnection. The CRS projects' capacity is for the 14 CRS facilities that would be affected by the MOs,
24249 which are a subset of the Bonneville resources.

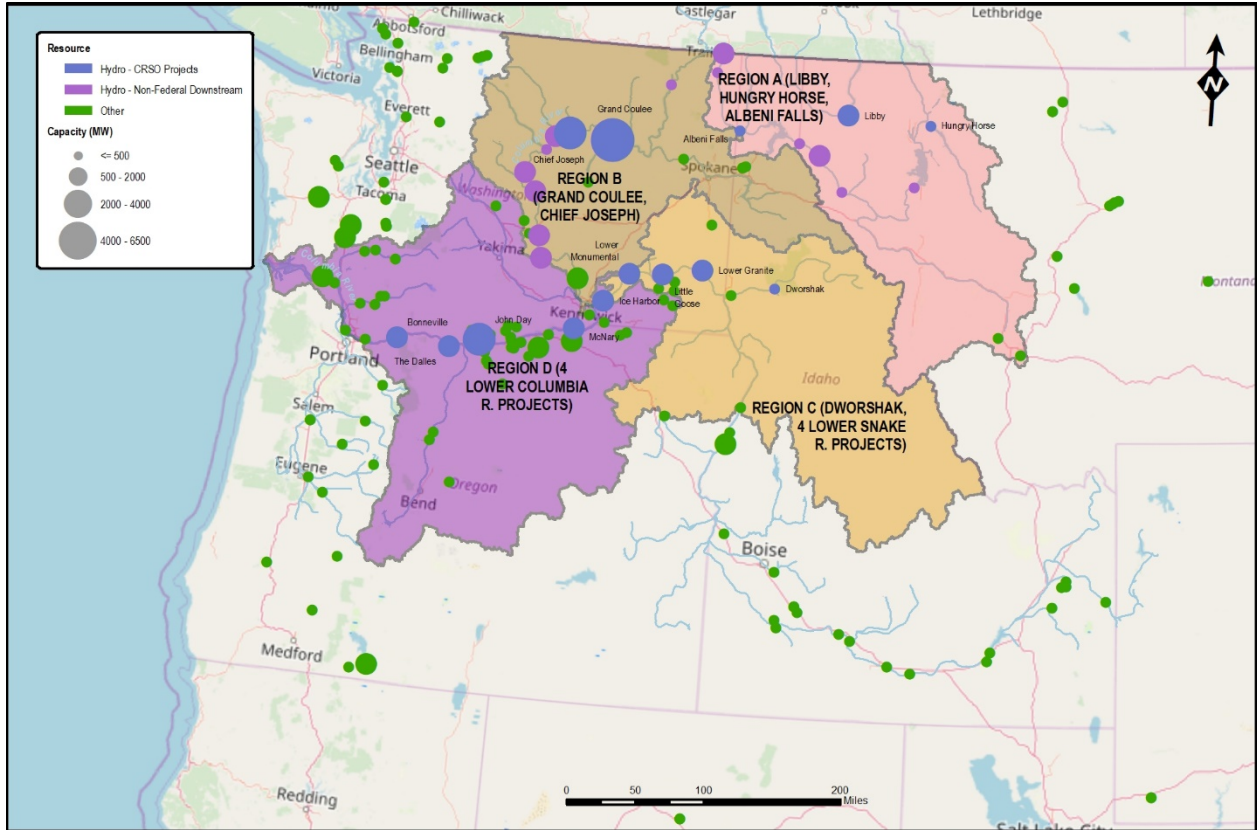
24250 1/ This column (Bonneville) represents the generation capacity of Bonneville's resources.

24251 2/ This statistic (Bonneville hydropower) represents the total capacity of the FCRPS hydro system, inclusive of the
24252 CRS projects.

24253 Source: Bonneville (2017b); NW Council (2018a); WECC (2018a)

24254 Total power generation (energy) in the Pacific Northwest fluctuated between 21,821 and
24255 27,407 aMW between 2002 and 2016 (NW Council 2018a). All hydropower (including the FCRPS
24256 and non-Federal hydro projects) provided at least 50 percent of the electric power generation
24257 every year (Figure 3-160), with wind increasing from less than 1 to 10 percent of the resource
24258 mix (113 to 2,687 aMW) over this period.

- 24259 • **Columbia River System Projects:** The 14 CRS projects that are the subject of the CRSO EIS
24260 are a subset of the 31-project FCRPS. Figure 3-159 highlights the CRS projects within the
24261 context of Pacific Northwest regional power resources. The projects are some of the largest
24262 power-generating resources in the region and constitute 34 percent of total Pacific
24263 Northwest regional capacity, with the potential to provide power to 6.6 million homes or
24264 roughly 1 million businesses, based on average consumption levels (EIA 2017c; NW Council
24265 2018a).



24266
24267 **Figure 3-159. Map of Pacific Northwest Generating Resources in 2018**
24268 Source: NW Council (2018a)

24269 **Table 3-109. Non-Federal Projects Downstream of the 14 Columbia River System Projects**

Project	MW Capacity
Seli's Ksanka Qlispe'	208.0
Thompson Falls	94.0
Noxon	518.0
Cabinet Gorge	265.5
Box Canyon	90.0
Boundary	1,039.8
Wells	774.3
Rocky Reach	1,299.6
Rock Island	623.7
Wanapum	1,038.0
Priest Rapids	955.6

24270 Source: NW Council (2018a)

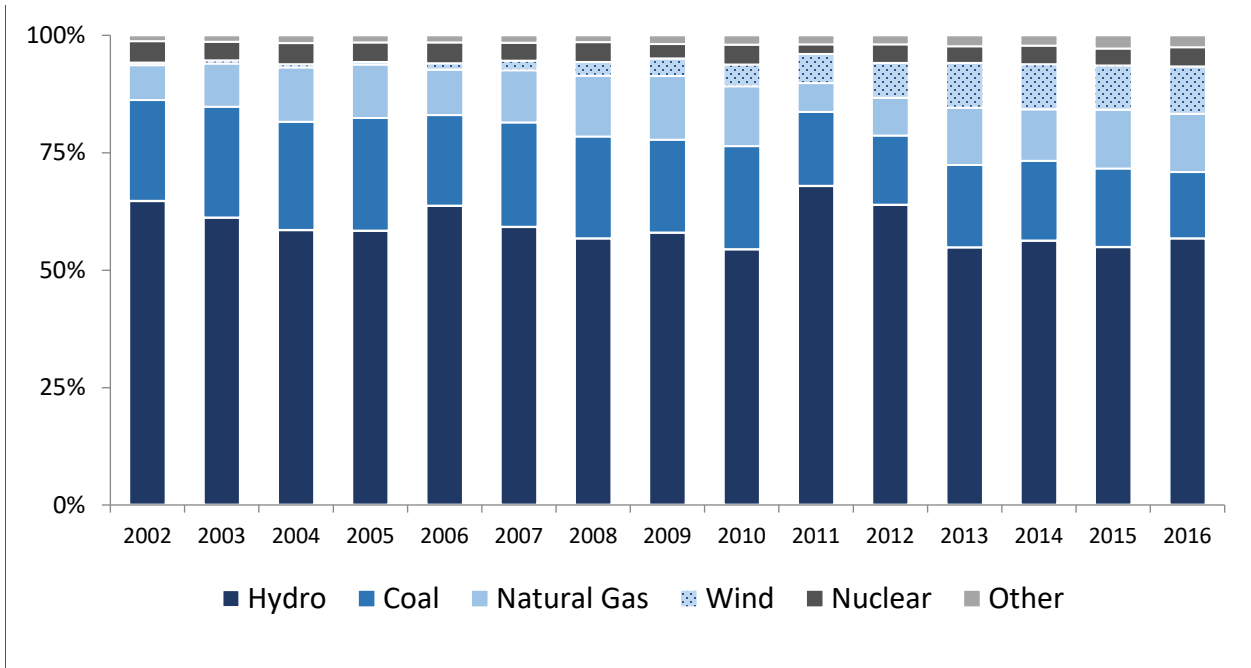


Figure 3-160. Breakdown of Annual Generation in the Pacific Northwest by Type from 2002 to 2016

Source: NW Council (2018a)

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Each of the CRS projects has one or more generation units with a specific capacity to produce power. The nameplate capacity (i.e., the maximum potential for energy output) for each CRS project ranges from 49 to 6,735 MW. Table 3-110 lists these projects and their generating characteristics, the largest of which is Grand Coulee located in northeastern Washington with a nameplate capacity of nearly 7,000 MW. The total combined capacity of all 14 CRS projects is 21,540 MW. This represents 96 percent of the 22,441 MW capacity of the FCRPS; average generation at these 14 projects constitutes 95 percent of the total energy of the FCRPS.

Table 3-110. Power Generation Characteristics of the 14 Columbia River System Projects

Plant	Units	Capacity (MW)	Average Generation (aMW) ^{1/}
Grand Coulee	24 ^{2/}	6,735 ^{2/}	2,396
Chief Joseph	27	2,614	1,355
John Day	16	2,480	1,097
The Dalles	22	2,052	823
Bonneville	18	1,195	556
McNary	14	1,120	633
Little Goose	6	930	296
Lower Granite	6	930	284
Lower Monumental	6	930	308
Ice Harbor	6	693	212
Libby	5	605	227
Dworshak	3	465	216

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Plant	Units	Capacity (MW)	Average Generation (aMW)^{1/}
Hungry Horse	4	428	87
Albeni Falls	3	49	21

24283 1/ 80-year average is identified using the aMW output from the FCRPS system as calculated using the water from
24284 the 80 years from 1929 to 2008.

24285 2/ The total number of generators and capacity at Grand Coulee does not include pump generator units, which
24286 provide 314 MW of capacity in limited periods of time.

24287 Source: Bonneville (2017b)

24288 These CRS projects operate below full capacity primarily because of the variation in available
24289 water, demand for electric supply, reservation of capability to maintain reliability, and
24290 constraints on project operation to achieve non-power objectives. An example of the annual
24291 variability of flows is illustrated in Figure 3-161, which includes annual water flow at The Dalles.
24292 In addition, the availability of water for hydropower is further limited by the need to address
24293 other congressionally authorized purposes of the CRS projects.³ Bonneville also considers the
24294 amount of generation available from the CRS projects that can be used to supply “reserves.”⁴
24295 Consequently, the CRS projects produce, on average, approximately 8,500 aMW (Bonneville
24296 2017b).

³ Electric power generated at Reclamation and Corps facilities required for the operation of each Federal project, including power needed for irrigation and municipal and industrial uses (pursuant to congressional authorization), is given priority; Bonneville markets only the power remaining.

⁴ Reserves are spare capacity on a generator (or in the case of the FCRPS, the interconnected and interdependent system of dams) to increase and sometimes to decrease generation so that electricity generation always equals demand for electricity. Reserves compensate for any of the following: (i) moment-to-moment differences between generation and load; (ii) larger differences occurring over longer periods of time during the hour; (iii) differences between a generator's schedule and the actual generation during an hour; and (iv) the portion of a generating unit's capacity that is held back, but which can immediately respond to the loss of another generator.

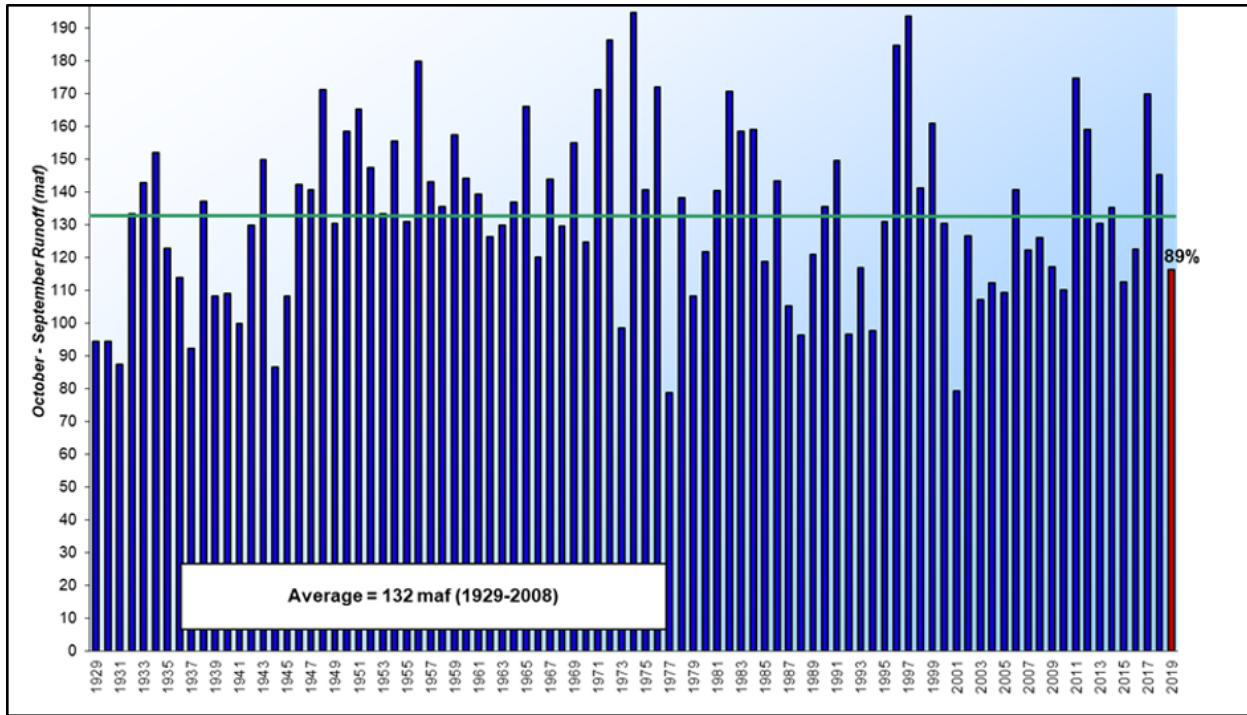


Figure 3-161. Annual Variability in Runoff at The Dalles in Million Acre-Feet, 1929 to 2019

Note: Maf is the equivalent volume of water that will cover an area of 1 million acres to a depth of 1 foot. Runoff forecasts are typically expressed in Maf.

Source: Northwest River Forecast Center (NWRFC) (2019)

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24302 **3.7.2.2 Power System Flexibility and Reliability**

24303 **SYSTEM RELIABILITY AND LOSS OF LOAD PROBABILITY (LOLP)**

24304 “Power system reliability” refers to the ability of the power supply to meet the demand, and
 24305 demand for power is typically referred to as “load.” The flexibility and capacity of the
 24306 hydropower system is critical to ensuring power system reliability. Power system reliability is
 24307 measured and discussed in terms of “loss of load probability” (LOLP) of the region’s power
 24308 supply. LOLP reflects the probability that the region’s expected supply of power will not be able
 24309 to meet the region’s demand for electricity.

24310 The NW Council sets the metric (e.g., LOLP) and target for reliability for the Pacific Northwest.
 24311 Created by the Northwest Power Act in 1980, the NW Council, develops both a regional power
 24312 plan and Bonneville’s Fish and Wildlife Program that together “ensure, with public
 24313 participation, an affordable and reliable energy system while enhancing fish and wildlife in the
 24314 Columbia River Basin.”⁵ The current standard for LOLP set by the NW Council in 2011 is
 24315 5 percent, meaning the power supply should have sufficient resources (both generating and
 24316 energy efficiency) to limit the likelihood of a shortfall to no more than 5 percent during a future
 24317 year, taking into account, for example, cold snaps in winter and heat waves in summer.
 24318 To measure adequacy, LOLP is calculated by dividing the number of simulations with shortfalls

⁵ See Northwest Power and Conservation Council, <https://www.nwcouncil.org/about/mission-and-strategy>.

24319 by the total number of simulations studied. For the power supply to be deemed adequate, that
24320 fraction must be less than 1/20, equating to an LOLP of 5 percent or less. When the power
24321 supply is unable to meet demand, customers could experience blackouts for brief or extended
24322 periods of time.

24323 Bonneville actively manages generation from its projects to ensure reliability. Electricity
24324 production at the CRS projects and other hydroelectric projects in the interconnected river
24325 system is influenced both by the turbine capacity and the amount of water available for
24326 generation. The amount of water available at each hydro project varies from year to year,
24327 season to season, day to day, and even hour to hour based on variation in flows, as well as
24328 operations constraints. The annual snowmelt in the spring leads to higher flows in the late
24329 spring and early summer with lower flows in late summer. FRM operations specify that
24330 reservoirs must be partially drafted by early spring (water discharged from the reservoirs so
24331 some of the high flows from the snowmelt can be stored in the reservoirs). Operations for
24332 endangered and other fish species, navigation, irrigation, and other resources also produce
24333 constraints on water management. Consequently, the ability for managing the timing of water
24334 flow through the Federal projects for power purposes is limited.

24335 When the river flows are high (e.g., the spring freshet) there is more water flowing through the
24336 turbines to produce hydropower. This extra generation can exceed the demand for the power
24337 from Bonneville's wholesale customers. In these circumstances, Bonneville sells the surplus
24338 power into wholesale electricity markets both within and outside the Pacific Northwest.
24339 In some years, the forecast made during the winter predicts a large spring runoff, so the
24340 storage projects are drafted (reservoir elevation lowered) very deep. However, if the late
24341 winter or early spring are unusually dry, Bonneville might not generate as much surplus power
24342 and could even be in a position of needing to purchase power on the wholesale market to meet
24343 demand and maintain reliability.

24344 Bonneville uses historical streamflow information to predict the pattern of water flow (and
24345 range of uncertainty in flows) to forecast how much it can generate during each month of the
24346 year. It then compares this forecasted generation to the forecasted demand for power.
24347 The storage capability of the CRS is less than the annual average streamflow and is further
24348 restricted to address FRM. In addition, further constraints on the use of the CRS for power
24349 production have occurred to support non-power objectives, primarily to support juvenile fish
24350 migration. While there is some flexibility in the hydrosystem to adjust river flows and
24351 generation to meet demand on a short-term basis, the operation of the river is constrained
24352 such that river flow dictates how much water is available for generation on a monthly or
24353 seasonal scale, and Bonneville uses purchases and sales on the wholesale market to balance the
24354 difference between its loads and resources (e.g., the FCRPS, Columbia Generating Station, and
24355 other resources acquired on a long-term basis).

24356 **MEETING SYSTEM UNCERTAINTY WITH GENERATION BALANCING RESERVES, DISPATCHABLE**
24357 **RESOURCES, AND RAMPING CAPABILITY**

24358 The demand for power changes constantly. Someone turns on a dishwasher, a business dims its
24359 lights in the evening, an electric forklift is plugged in for recharging, and countless other daily
24360 activities all lead to constant fluctuations in demand. At the same time, the supply of energy
24361 from solar and wind generation can vary with sunshine and wind gusts. To maintain reliability,
24362 sufficient generating capacity must be available at all times to meet system variability,
24363 balancing the changes in supply and demand. The spare capacity generators hold to respond to
24364 system increases or decreases is referred to as “generation balancing reserves.” Modifying the
24365 operations of hydroelectric or other generation facilities can affect the amount of generation
24366 balancing reserves available to the power system, and thus impact Bonneville’s ability to
24367 maintain power system reliability.

24368 Resources vary in their responsiveness to adjustments in demand. A resource that can adjust
24369 quickly to the changing need for generation is referred to as a “dispatchable resource.”
24370 Hydropower and natural gas-based combustion turbines are considered “dispatchable” because
24371 they can adjust production within minutes or seconds. Coal and nuclear in contrast are less
24372 dispatchable because they typically require at least 30 minutes to several hours to respond.
24373 Solar and wind resources are also very limited in their ability to be dispatchable given the
24374 variability to generate. For example, the wind may not blow nor the sun shine when the
24375 demand for power is high. As storage technologies (e.g., batteries) continue to develop allowing
24376 for storing of excess energy from wind and solar for future use, these renewable resources will
24377 become more dispatchable. Currently, however, hydropower and natural gas are the most
24378 dispatchable resources in the region and, as such, have a critical role in the ability of the system
24379 to meet demand.

24380 Another important attribute of a resource’s ability to meet demand is its ramping capability.
24381 Ramping capability is similar to dispatchability in that it measures a resource’s ability to move
24382 on short notice. Ramping capability, typically expressed in terms of a MW range, measures the
24383 amount of generation that the resource is able to increase or decrease over a defined time
24384 period.

24385 **3.7.2.3 Transmission**

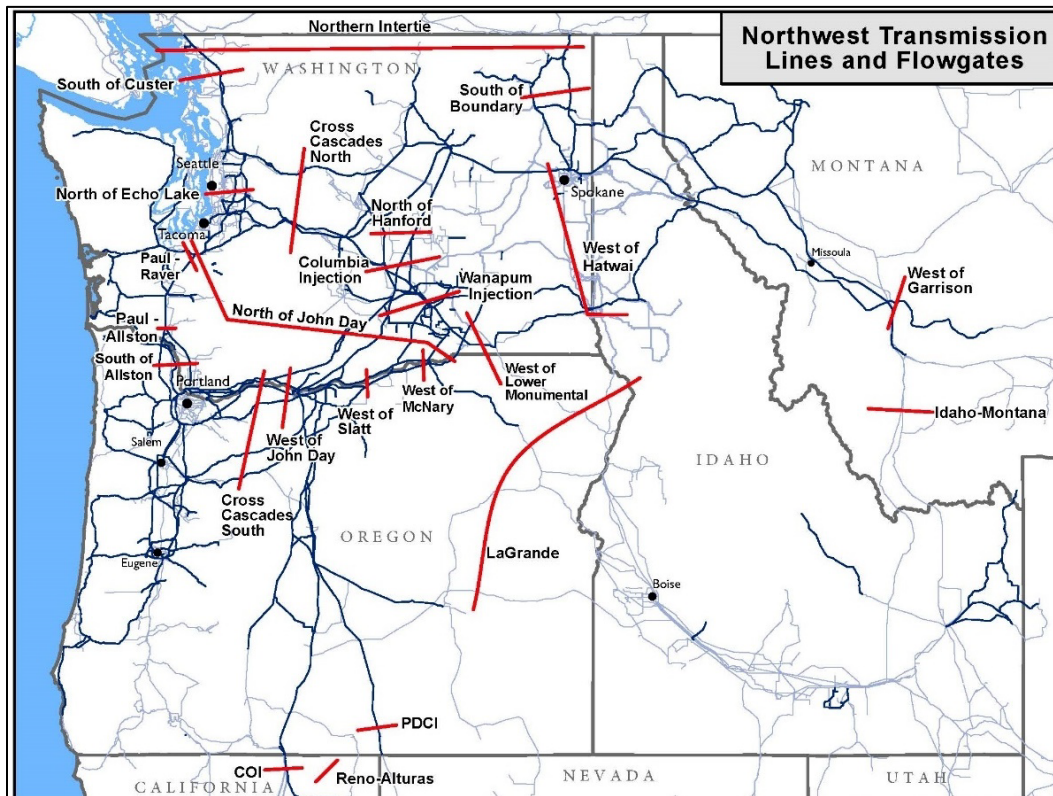
24386 The Western Interconnection is a network of roughly 130,000 circuit miles of transmission lines
24387 connecting all electric utilities in the West. Generation and load throughout the Western
24388 Interconnection must remain in balance continuously in order to ensure the reliable, stable,
24389 and secure delivery of power from generation resources to load.

24390 Within the Western Interconnection, electricity typically flows south and west to connect inland
24391 generating resources with population centers along the West Coast. Transmission connection
24392 points between different geographic areas enables generation and demand to be balanced
24393 across a wider footprint (e.g., transmission lines can carry power from the Pacific Northwest
24394 south to California and the Southwest during the spring or early summer, when hydropower

24395 generation is high and electricity demand is lower in the Pacific Northwest, to areas with higher
24396 summer demand).

24397 Bonneville's transmission system connects and moves power generated from Federal and non-
24398 Federal dams; nuclear, natural gas, and coal power plants; and solar and wind generation
24399 projects to load throughout the Pacific Northwest and beyond. Bonneville owns and operates
24400 about 15,000 circuit miles of high-voltage transmission lines and associated substations in the
24401 Pacific Northwest. There are over 260 Bonneville substations that collect power, control the
24402 flow of power, and deliver electricity to Bonneville customers. Besides the transmission system
24403 within the Pacific Northwest, interregional transmission lines also connect Bonneville to
24404 Canada, California, the southwestern United States, and eastern Montana.

24405 Electricity moves over Bonneville's transmission system through managed flow paths that
24406 consist of one or more high-voltage transmission facilities and transmission lines. As shown in
24407 Figure 3-162, Bonneville's transmission system contains multiple "paths," or routes over which
24408 power flowing from one point to another is monitored and managed.⁶



24409
24410 **Figure 3-162. Northwest Transmission Paths**

24411 Note: The blue lines represent actual Bonneville transmission lines, and the red lines denote defined paths,
24412 interties, and flowgates (locations where power flows are monitored and analyzed). Transmission lines not
24413 operated by Bonneville are in light gray-blue.

24414 Source: Bonneville (2018a)

⁶ See glossary for additional definitions of interties, flowgates, and transmission paths.

24415 **BONNEVILLE TRANSMISSION FLOWS AND LOAD AREAS**

24416 The flow of electricity on the transmission system is a function of the quantity and location of
24417 the loads, the amount and location of the generation deployed to meet these loads, and the
24418 electrical parameters of the transmission facilities. Flow patterns vary daily throughout the
24419 year. Hydropower and fossil fuel generation tends to serve peak loads during the winter when
24420 there are high electricity flows running from the east to load centers in western Washington
24421 and western Oregon. During the spring, runoff from snowmelt and storage releases from
24422 reservoirs such as Grand Coulee and Hungry Horse contribute to relatively elevated flows
24423 compared to other times of the year. This runoff results in surplus power that can be exported
24424 to other regions, resulting in higher electricity flows north to south on the transmission system.
24425 This north-to-south transmission flow path also experiences peak demand during the summer
24426 when air conditioning and other uses that influence seasonal peaks place an increased demand
24427 on the system.

24428 Although the location of the loads and their seasonality are not likely to shift from year to year,
24429 variations in generation across the resource mix can change the flow of power within the
24430 Bonneville transmission system. Changes in precipitation patterns and runoff, and changes in
24431 the timing and availability of wind and solar power, all have the potential to influence flows
24432 across the transmission system. For example, heavy rains or rapid snowmelt along the lower
24433 Snake River could result in more water moving through hydropower turbines, increasing
24434 generation. This results in increased east-to-west transmission flows in southeast Washington.
24435 In addition, recent increases in renewable generation (i.e., wind and solar generation) have
24436 increased certain flows such as south-to-north flows for California solar at mid-day. Further, the
24437 rapid development of new, large industrial loads—such as server farms-- at times can also
24438 introduce changes in the flow of power within the Bonneville transmission system.

24439 **TRANSMISSION RELIABILITY AND CONGESTION**

24440 Impacts to transmission flows due to changes in generation and load can affect transmission
24441 system reliability and congestion. Congestion occurs when a transmission path, line, or facility is
24442 near or close to its operating limit. Transmission system reliability refers to the ability or
24443 inability of the transmission system to deliver energy to serve a load (by contrast, power system
24444 reliability, as noted previously, refers to the ability of the power supply to meet the demand, or
24445 load).

24446 Under Section 215 of the Federal Power Act, Pub. L. No. 109-58, 119 Stat. 594 (codified at
24447 16 U.S.C. § 824o), FERC has responsibility over the adoption and enforcement of national
24448 standards that govern the reliability and security of the bulk power system. The Electric
24449 Reliability Organization, currently the North American Electric Reliability Corporation (NERC),
24450 has the authority to develop and enforce reliability standards, subject to FERC approval and
24451 oversight. In turn, NERC has delegated its authority to Regional Entities with responsibility for
24452 developing regional reliability standards and enforcing all standards within the Regional Entity's
24453 area. The Western Electricity Coordinating Council (WECC) is the Regional Entity for the
24454 Western Interconnection.

24455 Reliability standards are in place to minimize the frequency and severity of power outages,
24456 protecting public health and safety, and avoiding economic disruptions. Reliability standards
24457 include requirements to ensure system stability and voltage support (keeping voltage levels
24458 within a given range), to provide reserves in case of contingencies, and to provide reserves and
24459 automatic generation response to meet ever-changing loads. Flexible generating resources are
24460 vital to meeting these reliability standards.

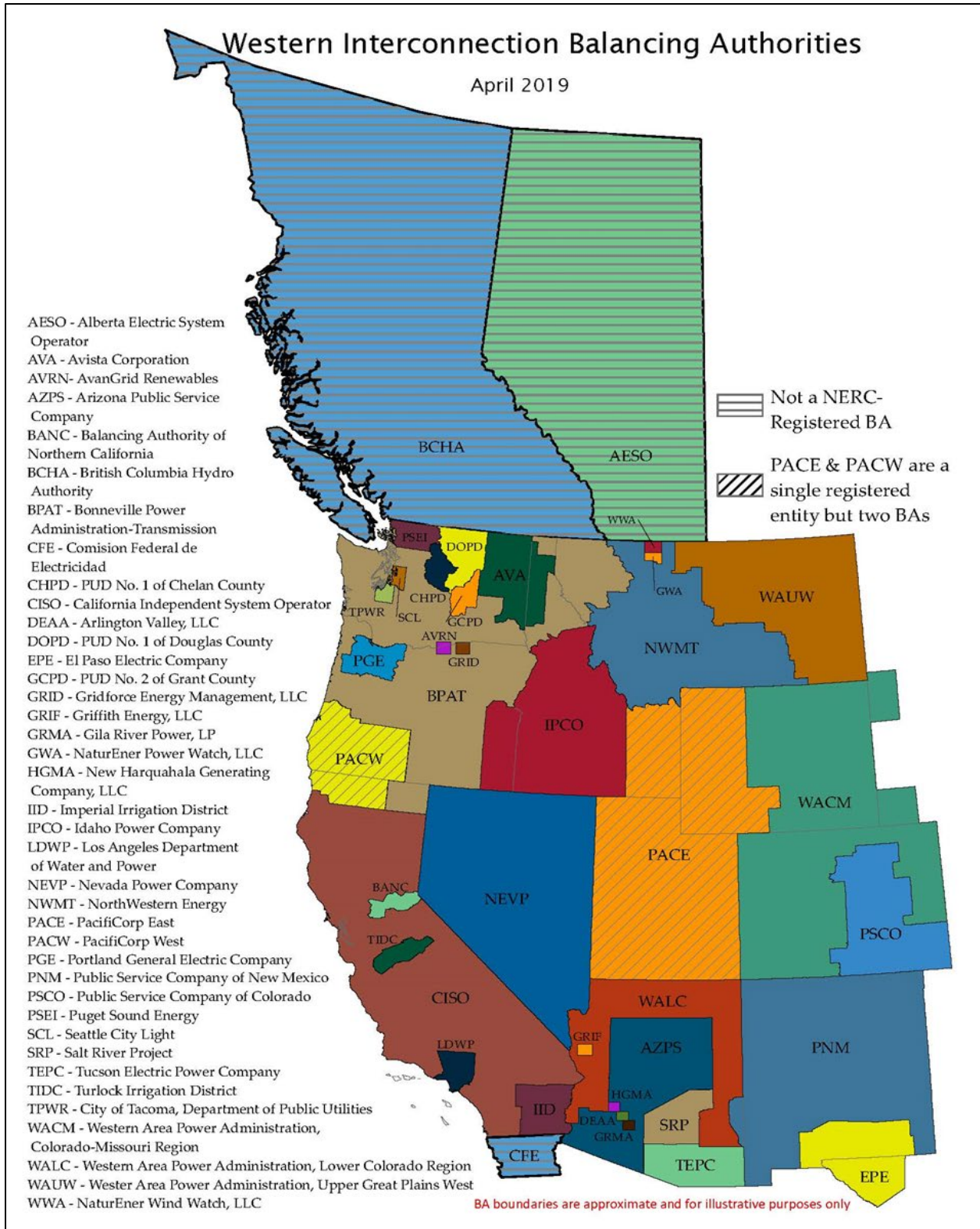
24461 The reliability standards establish various functional entities with responsibility over different
24462 aspects of transmission system reliability. Bonneville performs the roles of balancing authority
24463 (BA), transmission operator, transmission owner, transmission planner, and planning
24464 coordinator.⁷ As a BA, Bonneville is responsible for maintaining balance between resources and
24465 loads within its balancing authority area (BAA) in real time (minute by minute) by dispatching
24466 generating resources within its BAA, thereby ensuring power is provided to meet load (“load
24467 service”). Typically generating resources within the BAA are connected to automatic generation
24468 control so that the resources can respond instantly to deviations in expected load and
24469 generation levels.

24470 The BAs in the Western Interconnection (Figure 3-163) all contribute to supporting the
24471 reliability of the interconnection, in part, by exchanging power with other BAs when other BAs
24472 are out of balance and cannot address the imbalance with the BA’s own resources.

24473 As a transmission operator, Bonneville must operate transmission paths, facilities, and lines
24474 within certain operating limits. Changes in supply, demand, pricing, and/or operational
24475 availability of specific grid-related assets all influence congestion and methods to relieve
24476 congestion (U.S. Department of Energy 2014). Congestion can increase the cost of serving loads
24477 by forcing utilities to obtain power from alternative resources that are more costly.
24478 If alternative resources are unavailable, congestion could lead to a disruption in service.
24479 Increases in transfer capability (the ability to transfer electricity across a transmission path)
24480 through appropriate transmission system reinforcements or reducing demand on the system,
24481 such as through demand response and energy-efficiency measures, are methods used to relieve
24482 congestion on the transmission system and maintain reliability.⁸ In addition, as a transmission
24483 operator, Bonneville must be prepared to curtail transmission, reconfigure transmission,
24484 redispatch generation (decreasing generation to relieve the overloaded transmission path,
24485 facility, or line and increasing generation elsewhere on the system to ensure load service), or
24486 implement a controlled interruption of electrical service (blackout) to a local area to maintain
24487 flows within limits. Otherwise, Bonneville risks equipment damage or, in extreme cases,
24488 uncontrolled blackouts.

⁷ See *NERC Reliability Functional Model*, v.5.1 (Dec. 12, 2018).

⁸ Demand response is a set of resources or tools that allow utilities to reduce electricity consumption through programmable products or options. Demand response tools allow electricity providers and consumers to better manage how and when they consume electricity and, in some cases, at what price. Demand response can include actions such as temporarily turning off hot-water heaters or adjusting a building’s temperature to reduce demand during peak-demand periods. Energy efficiency measures introduce more efficient equipment and household appliances to decrease the amount of electricity needed.



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Figure 3-163. Balancing Authorities in the Western Interconnection

Note: The Bonneville BA is labeled “BPAT,” which can be seen in the southeast corner of Oregon. Boundaries are approximate and are for illustrative purposes only.

Source: WECC (2017)

24494 As a transmission owner, Bonneville has the responsibility to maintain and protect its
24495 transmission facilities and lines to ensure that they operate reliably. Finally, as a transmission
24496 planner and planning coordinator, Bonneville must plan its transmission system so that it can
24497 meet demand without overloading transmission lines and facilities or causing instability.

24498 **3.7.2.4 Power and Transmission Coordination**

24499 Real-time management of the CRS projects relies on a high degree of coordination among
24500 Bonneville, which operates and maintains the Federal transmission system, and the Corps and
24501 Reclamation, which operate the CRS projects. Bonneville is responsible for ensuring it has
24502 sufficient resources available to meet its contractual power obligations. In the event the
24503 Administrator cannot be assured on a planning basis of acquiring sufficient resources to meet
24504 Bonneville’s power supply obligations, the Administrator may issue a notice of insufficiency to
24505 all firm power customers. Such a notice allows Bonneville to restrict and physically allocate the
24506 remaining power among the firm power customers. Given an insufficiency of resources, there
24507 would likely be significant impacts to transmission system operations. In power emergency
24508 situations or in the case of an imminent power emergency, Bonneville, in coordination with the
24509 Corps and Reclamation, can implement a variety of measures to prevent disruption in service,
24510 such as temporarily spilling less water so that more water is run through the turbines to
24511 produce power.

24512 In the case of transmission system congestion, Bonneville transmission operators can dispatch
24513 Federal generation to address the power flows that are contributing to the congestion or
24514 reliability issues. For example, in 2016, due to transmission congestion leading into the Tri-
24515 Cities area in southeastern Washington, high loads, and spill at Ice Harbor Dam, a transmission
24516 system emergency was declared in order to interrupt spill and increase generation at Ice Harbor
24517 Dam. This action prevented overloading the congested transmission facilities in the area and
24518 ensured load service. Absent the ability to increase generation under such circumstances,
24519 equipment damage and/or the loss of load (i.e., blackouts) could result.

24520 **3.7.2.5 Bonneville Power and Transmission Customers**

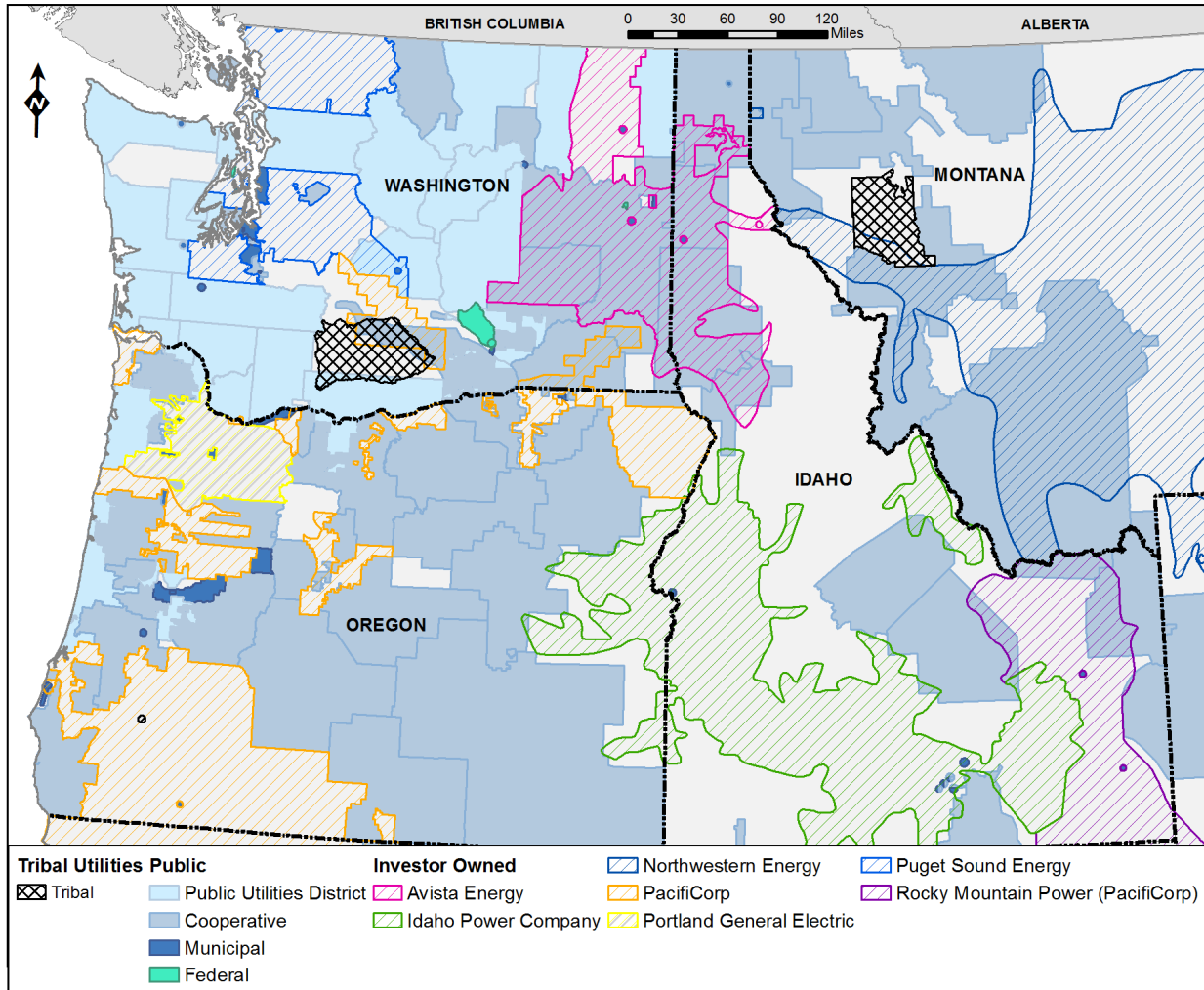
24521 **FIRM POWER CUSTOMERS**

24522 In its role as the designated marketing agent for the power produced by the FCRPS, Bonneville
24523 is statutorily required to provide preference and priority in selling power to public bodies and
24524 cooperatives, including tribal utilities (“preference customers”).⁹ Bonneville also sells power to
24525 IOUs, Federal agencies, and DSIs. All of these customers purchase “firm” power from
24526 Bonneville, which is power that is guaranteed to be continuously available, except for reasons
24527 of force majeure. These entities are referred to as “firm power customers” when purchasing
24528 power from Bonneville pursuant to Sections 5(b), (c), and (d) of the Northwest Power Act.
24529 Bonneville has 136 firm power customers that include 135 public and Federal agencies and

⁹ See Bonneville Project Act, § 4(a), 16 U.S.C. § 832c(a) (2018).

24530 1 DSI customer (Bonneville 2018a).¹⁰ None of the region’s IOUs are currently buying firm power
 24531 under long-term contracts.¹¹

24532 Figure 3-164 presents a map of the service areas of Bonneville’s utility customers.



24533
 24534 **Figure 3-164. Bonneville Utility Customers in the Pacific Northwest**
 24535

Source: Bonneville (2018a)

¹⁰ Bonneville’s remaining DSI customer is a paper mill.

¹¹ Regional IOUs are participating in the Residential Exchange Program, which is a statutory program that permits utilities with high cost resources to sell the output of those resources to Bonneville and, in exchange, purchase an equivalent amount of power from Bonneville. The net difference between these sales results in a payment to the IOUs. The Residential Exchange Program is implemented as a paper exchange, with no actual energy delivered. See [Residential Exchange Program](#) under Power Revenue Requirement below for full description.

24536 **SURPLUS POWER SALES**

24537 Power produced by the Federal Base System,¹² which includes the FCRPS, that is surplus to
24538 Bonneville’s firm power obligations can be sold as “surplus.” Surplus power includes
24539 uncommitted firm power that is produced under critical water conditions and non-firm, or
24540 secondary power, which is produced when water conditions are above critical levels
24541 (*i.e.*, average water conditions). Bonneville markets this surplus power to a mix of public,
24542 private, and extra-regional customers throughout the Western Interconnection through
24543 wholesale power markets.

24544 **COMPETITIVE PRESSURE ON BONNEVILLE’S POWER RATES**

24545 Bonneville’s current firm power sales contracts with preference customers expire in 2028. After
24546 2028, these customers will have a choice to either purchase from Bonneville or from other
24547 power suppliers. A key factor influencing the power supplier decision will be Bonneville’s
24548 expected firm power rates compared to other choices in the wholesale power market (*i.e.*, the
24549 “spot market”). Over the past decade, the average spot market price for power has steadily
24550 declined due to the abundance of low-cost natural gas and the large-scale development of
24551 variable renewable energy resources, such as wind and solar. During this time, Bonneville’s
24552 power rates have increased due to cost increases in several programs related to the operation
24553 of the Columbia Generating Station, investments associated with Federal infrastructure,
24554 Endangered Species Act requirements, implementation of the Columbia Basin Fish Accords, and
24555 the effect from decreased secondary sales revenue due to lower market prices. It is important
24556 to note the spot market price is not directly comparable to Bonneville’s rates because
24557 Bonneville provides a high-quality power product that is backed by Federal Base System
24558 resources, which includes the FCRPS and the Columbia Generating Station. Bonneville’s firm
24559 power customers, thus, receive a power product that provides a reliable and stable supply of
24560 power at predictable prices set by Bonneville’s statutory process. Spot market purchases, in
24561 contrast, are volatile, with supply not assured and pricing subject to market spikes.

24562 Preference customers have, nonetheless, pointed to the sustained divergence in spot market
24563 prices and Bonneville’s rates as evidence of the diminishing long-term affordability of Federal
24564 power. Almost 80 cents of every dollar of power revenue Bonneville receives comes from sales
24565 of firm power to preference customers; thus, maintaining sales to these customers is vital in
24566 order for Bonneville to continue to recover its costs and provide affordable Federal power to
24567 Pacific Northwest residents and businesses.

24568 Bonneville has taken steps to manage its costs so that Federal power remains competitive and
24569 affordable for the long term. As part of those steps, Bonneville has developed a 2018–2023
24570 Strategic Plan that includes a goal of providing competitive power products and services at low,
24571 competitive rates. The most recent of these steps was taken in the BP-20 rate period, in which

¹² Federal Base System means (A) the FCRPS, (B) resources acquired by Bonneville under long term contracts on December 5, 1980, and (C) resources acquired by Bonneville in amounts needed to replace reductions in the capability of the resources referred to in (A) and (B). See 16 U.S.C. § 839a(10).

24572 Bonneville was able to adopt a flat base power rate, i.e., no rate increase, for fiscal years 2020-
24573 21. While this was a first step, Bonneville will need to maintain its new rate trajectory over the
24574 next eight years and into the term of its new contracts to provide adequate, efficient,
24575 economical, and reliable power supply in 2028. For this reason, sustaining Bonneville’s
24576 competitiveness remains a core focus of the agency. The risks associated with achieving this
24577 goal in light of the MOs in this EIS are described in Section 3.7.3.1, *Base Case Methodology and*
24578 *Cost Sensitivities Analysis*.

24579 **TRANSMISSION CUSTOMERS**

24580 Bonneville provides transmission services and associated ancillary services to more than 300
24581 customers, including PUDs, DSIs, municipalities, cooperative utilities, IOUs, Federal agencies, a
24582 port district, tribal utilities, independent power producers, and power marketers. Bonneville’s
24583 transmission customers extend largely throughout the Western Interconnection, the
24584 boundaries of which are depicted in Figure 3-157. Bonneville also has “generator
24585 interconnection” customers that have connected non-Federal generating facilities to
24586 Bonneville’s transmission system.

24587 **3.7.2.6 Power and Transmission Rate Case**

24588 Establishing Bonneville’s wholesale power and transmission rates is a complex public process
24589 set forth in the Northwest Power Act. The process is referred to as a “rate case” and is subject
24590 to the rate-making procedures in Section 7(i) of the Northwest Power Act.¹³ Bonneville is
24591 obligated to periodically review and revise rates to ensure cost recovery, but not less frequently
24592 than every 5 years. Currently Bonneville conducts a rate case every 2 years to establish power
24593 and transmission rates for the next 2-year rate period. The current rates, referred to as BP-20
24594 rates, were developed as part of the rate case undertaken in 2019. The rates for Bonneville’s
24595 power sales are separate from the rates for transmission services.

24596 **3.7.2.7 Power Rate Determination**

24597 Power rates are calculated based on an iterative process that involves three general
24598 components: (1) a forecast of expected supply from federally owned or acquired resources;
24599 (2) a forecast of firm (and non-firm) power sales commitments (referred to as “forecasted
24600 load”); and (3) a forecast of costs to be recovered from the forecasted load over the rate period
24601 (“revenue requirement”). The components of the rates analysis are described briefly below.

24602 **POWER SUPPLY**

24603 **Firm Power**

24604 Bonneville forecasts the expected firm power from the FCRPS by modelling expected
24605 generation under critical water conditions. The historic water year of 1937 (October 1936 to
24606 September 1937) is referred to as the “critical water year.” Critical water year or critical water

¹³ 16 U.S.C. § 839e(i) (2018).

24607 conditions represent the historic water conditions under which the capability of the hydro
 24608 system produces the least amount of dependable generation while considering power and non-
 24609 power operating constraints. Modelling expected generation under critical conditions includes
 24610 accounting for the following power and non-power operations: FRM constraints; the Columbia
 24611 River Treaty with Canada; the Endangered Species Act Biological Opinion requirements;
 24612 meeting reclamation/irrigation and other water supply requirements; and transmission system
 24613 support. The power generated while meeting these operational needs under critical water
 24614 conditions is available to supply as firm power.

24615 **Surplus Power**

24616 Surplus power refers to energy or capacity that remains after Bonneville’s total firm power
 24617 obligations have been met. Surplus power generally comes in two forms. “Surplus firm power”
 24618 is power produced by the Federal dams based on modeling under critical water conditions;
 24619 surplus firm power includes power from Bonneville’s other, non-hydropower system resources.
 24620 Non-firm or “secondary surplus power” is power produced by the Federal dams based on
 24621 modeling of better than water conditions; secondary surplus power only includes the increase
 24622 in power generation capability from hydropower resources. Average water conditions refers to
 24623 the amount of power the FCRPS would likely produce assuming the 80-year average generation
 24624 (based on historical water flow from 1929 to 2008).

24625 Table 3-111 compares firm energy and average energy generation for the CRS projects.
 24626 The difference between the amount of firm power produced under critical water conditions
 24627 (“Firm Energy” column) and the amount of energy produced under 80-year average generation
 24628 (“80-Year Average Generation” column) approximates the average secondary surplus energy
 24629 (“Average Secondary Surplus Energy” column). Secondary surplus power is sold on the
 24630 wholesale markets or through other contractual arrangements. Any revenue from the sale of
 24631 surplus power serves to reduce the rates that Bonneville charges to its firm power customers.

24632 **Table 3-111. Generation at the Columbia River System Projects**

Project	Firm Energy (aMW)	80-Year Average Generation (aMW)	Average Secondary Surplus Energy (aMW)
Grand Coulee	1,908	2,396	488
Chief Joseph	1,116	1,355	239
John Day	784	1,097	313
The Dalles	599	823	224
Bonneville	390	556	166
McNary	478	633	155
Little Goose	160	296	136
Lower Granite	147	284	137
Lower Monumental	149	308	159
Ice Harbor	109	212	103
Libby	187	227	40
Dworshak	140	216	76

Project	Firm Energy (aMW)	80-Year Average Generation (aMW)	Average Secondary Surplus Energy (aMW)
Hungry Horse	74	87	13
Albeni Falls	20.4	20.8	0.4
Total	6,261 aMW	8,511 aMW	2,249 aMW

24633 Note: One aMW is equal to 8,760 MWh.

24634 Source: Bonneville (2017b)

24635 **FIRM LOAD FORECAST**

24636 Load is the measure of demand for electric power by end users. End user consumption is
24637 referred to as “retail load.” Retail load fluctuates on a daily and seasonal basis but is fairly
24638 predictable over the course of a year, resulting in predictable patterns or “shapes” that reflect
24639 the size and timing of demand. Bonneville and regional utilities reference these load shapes to
24640 forecast demand for electricity for planning purposes.

24641 Bonneville’s preference customer load forecast in the BP-20 rate case was 6,714 aMW.
24642 Bonneville forecasts the total retail load of each of its utility customers including each utility’s
24643 “peak load,” the maximum demand for electricity during a time period (EIA 2017d; EIA 2018a).
24644 The “net requirement for power” that Bonneville is obligated to supply relies on forecasting
24645 each utility’s load, peak loads, and the projected output of the utility’s own resources (if any).
24646 The total load across the region has remained relatively constant over the past decade with
24647 small increases in the peak loads, except in areas such as The Dalles, Boardman, and Central
24648 Oregon where there have been larger amounts of industrial load growth associated with data
24649 centers and other development.

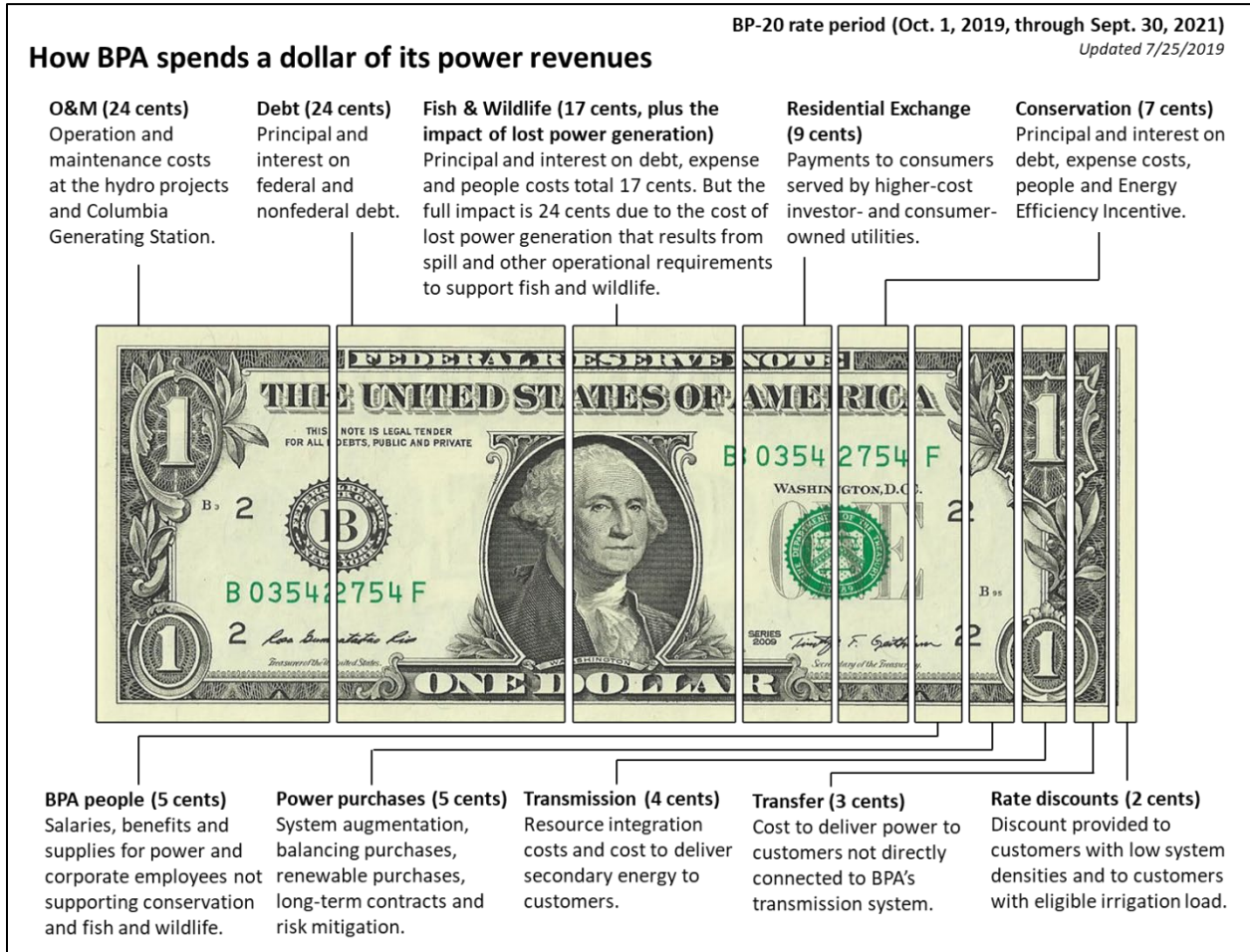
24650 Peaks can be examined for an hour, a single day, weekly, or monthly. Bonneville also considers
24651 “sustained peaking capacity” (6 peak hours per weekday for a month, or super peak capacity) of
24652 the FCRPS to determine how much power could be delivered should an extended peak occur
24653 such as a cold snap or heat wave. Seasonal patterns of power use across Bonneville’s
24654 transmission system reflect winter peaks (highest loads occur in November through February).
24655 Most areas west of the Cascade Range are winter peaking, with summer (June through
24656 September) peaks in just a few of these areas (FERC 2016; NW Council 2016; EIA 2017d).

24657 **POWER REVENUE REQUIREMENT**

24658 Bonneville is a self-funded, not-for-profit government entity that is required by statute to
24659 ensure that the rates it charges are set to recover its costs consistent with sound business
24660 principles. Bonneville recovers its costs by establishing a “revenue requirement,” which is a list
24661 of projected costs for a rate period that must be paid by revenues generated from rates. The
24662 revenue requirement for power rates is comprised of three major categories:

- 24663 • Program costs (O&M, employee costs, fish & wildlife, conservation)
- 24664 • Debt payments including principal and interest
- 24665 • Costs calculated through the rate setting process (Residential Exchange Program, power
24666 purchases, cost of transmission, and rate discounts).

24667 The projected program costs are discussed through a public process, the Integrated Program
24668 Review, prior to the initiation of the rate setting process.



24669
24670 **Figure 3-165. BPA Power Revenues**

24671 The generation costs for the CRS projects (per MWh) vary considerably among the larger
24672 facilities, with costs for John Day at \$4.70 per MWh, and Bonneville at \$17 per MWh
24673 (Bonneville, Corps, and Reclamation 2016). Costs vary due to a variety of factors including
24674 operations and maintenance, the age of generators and associated depreciation, and fish
24675 management. Table 3-112 shows the total generation for 2015 and the cost per project and per
24676 MWh.

24677 **Table 3-112. Generation Costs of the Columbia River System Projects**

Plant	80-Year Average Generation (aMW)	Fiscal Year 2015 Total Cost (thousands of dollars)	Average Cost of Generation (\$/MWh)
Grand Coulee	2,396	191,252	9.1
Chief Joseph	1,355	65,435	5.5
John Day	1,097	42,937	4.5
The Dalles	823	36,619	5.1
Bonneville	556	83,989	17.2

Plant	80-Year Average Generation (aMW)	Fiscal Year 2015 Total Cost (thousands of dollars)	Average Cost of Generation (\$/MWh)
McNary	633	35,675	6.4
Little Goose	296	26,589	10.3
Lower Granite	284	32,652	13.1
Lower Monumental	308	25,628	9.5
Ice Harbor	212	22,088	11.9
Libby	227	31,415	15.8
Dworshak	216	20,232	10.7
Hungry Horse	87	10,450	13.7
Albeni Falls	20.8	9,630	52.9
Total	8,511	634,591	8.5

24678 Note: One aMW is equal to 8,760 MWh.

24679 Source: Bonneville, Corps, and Reclamation (2016)

24680 A variety of cost factors other than operations and maintenance of FCRPS generating resources
24681 and repaying the U.S. Treasury for debt related to these projects are included in the power
24682 revenue requirement and directly affect power rates. These include, but are not limited to the
24683 following:

- 24684 • **Residential Exchange Program:** The Northwest Power Act requires Bonneville to acquire
24685 power from utilities with high cost resources and sell them lower cost Federal power. This is
24686 known as the Residential Exchange Program (REP). Historically under this program, actual
24687 power is not exchanged but Bonneville pays the participating utility the difference between
24688 the cost of their power and the cost of Bonneville’s power. The REP was created to mitigate
24689 wholesale rate disparity between Bonneville’s preference customers and regional IOUs.

- 24690 • **Bonneville Energy Efficiency and Demand Response Programs:** The NW Council’s Power
24691 Plan includes energy-efficiency targets for Bonneville and the Pacific Northwest utilities that
24692 are based in programs designed to reduce end user loads through conservation (e.g.,
24693 installing appliances or light fixtures that require less electricity). Bonneville is also testing a
24694 variety of demand-response pilot programs that would help manage electricity
24695 consumption.

- 24696 • **Bonneville Fish and Wildlife Program and Lower Snake River Compensation Plan:**
24697 Bonneville’s Fish and Wildlife Program funds hundreds of projects each year to mitigate the
24698 impacts of the development and operation of the Federal hydropower system on fish and
24699 wildlife. Bonneville began this program to fulfill mandates established by Congress in the
24700 Northwest Power Act to protect, mitigate, and enhance fish and wildlife affected by the
24701 development and operation of the FCRPS. Each year, Bonneville funds projects with many
24702 local, state, tribal, and Federal entities to implement offsite mitigation actions listed in
24703 various Biological Opinions for ESA-listed species. Offsite protection and mitigation actions
24704 typically address impacts to fish and wildlife not caused directly by the CRS, but they are
24705 actions that can improve the overall conditions for fish to help address uncertainty related
24706 to any residual adverse effects of CRS management. For example, Bonneville’s F&W

24707 Program funding improves habitat in the mainstem as well as tributaries and the estuary,
24708 builds hatcheries and boosts hatchery fish production, evaluates the success of these
24709 efforts, and improves scientific knowledge through research. This work is implemented
24710 through annual contracts, many of which are associated with multi-year agreements like the
24711 Columbia River Basin Fish Accords, the Accord extensions, or wildlife settlements. To make
24712 the most of available funds, investments in fish and wildlife mitigation are prioritized based
24713 on biological and cost effectiveness and their connection to mitigating for impacts to the
24714 CRS. Funding decisions for the Bonneville Fish and Wildlife Program are not being made as a
24715 part of the CRSO EIS process. However, a range of potential F&W Program costs are
24716 included to inform the potential power revenue requirements for each alternative in this
24717 chapter and to inform the broader cost analysis for each alternative in Section 3.18. Future
24718 budget decisions would be made with regional input through Bonneville's budget-making
24719 processes and other appropriate forums and consistent with existing agreements.

24720 Bonneville also directly funds the annual operations and maintenance of the Lower
24721 Snake River Compensation Plan (LSRCP) facilities. Congress authorized the LSRCP as part
24722 of the Water Resources Development Act of 1976 (90 Stat.2917) to offset fish and
24723 wildlife losses caused by construction and operation of the four lower Snake River
24724 projects. A major component of the authorized plan was the design and construction of
24725 fish hatcheries and satellite facilities. The LSRCP is administered through the U.S. Fish
24726 and Wildlife Service (USFWS). The LSRCP hatcheries and satellite facilities produce and
24727 release more than 19 million salmon, steelhead, and resident rainbow trout annually as
24728 part of the program's mitigation responsibility. The 25 LSRCP hatcheries and satellite
24729 facilities are operated by Idaho Fish and Game (IDFG), Washington Department of Fish
24730 and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), USFWS, the Nez
24731 Perce Tribe (NPT), Confederated Tribes of the Umatilla River (CTUIR), and Shoshone-
24732 Bannock Tribes (SBT). LSRCP would be continued, consistent with the No Action
24733 Alternative, under all of the MOs except for MO3.

- 24734 • **Low Density Discounts:** The Northwest Power Act includes provisions for a low-density
24735 discount to compensate customers with unusually high distribution costs because of
24736 geographic location.
- 24737 • **Irrigation Rate Discounts:** Historically, Bonneville has provided discounts to customers who
24738 serve rural agricultural loads. Irrigation rate discounts support the mission of Bonneville and
24739 the FCRPS to provide economic power to all customers across the region.¹⁴

24740 The environmental consequences analysis relies on the expense forecast developed as part of
24741 the BP-20 rate case. This forecast considers capital expenses, Bonneville Fish and Wildlife
24742 Program costs, and various structural and operational costs, and how these vary under each
24743 MO.

¹⁴ These discounts are not to be confused with Reclamation Project Use Power for irrigation delivery for authorized loads.

24744 **POWER RATE CALCULATION**

24745 Bonneville currently uses a tiered rate methodology (TRM), adopted in 2008, to set the priority
24746 firm (PF) power rates for power sold under the Regional Dialogues power sales contracts. As a
24747 key feature of the TRM, prior to the rate case, Bonneville evaluates the rate period high water
24748 mark (RHWM), which is the maximum planned amount of firm power supplied by the FCRPS
24749 and acquired resources that can be sold at Tier 1 rates. This type of power is called Tier 1
24750 System Capability and is sold at Tier 1 rates. (For a sense of scale, Tier 1 rates average around
24751 \$36 per MWh under the No Action Alternative.) The RHWM is based on forecasted FCRPS
24752 generation under 1937 critical water conditions and expected customer load. The RHWM is
24753 established just prior to each rate case and is set for the rate period. After calculating the costs
24754 and credits included in the revenue requirement described above, the expected revenues from
24755 the forecast of sales of secondary surplus energy on the wholesale market are allocated as a
24756 reduction in the revenue requirement. This net cost divided by the forecast of firm power
24757 necessary to meet expected demand is the Tier 1 rate for a Bonneville preference customer. If a
24758 preference customer's load exceeds its RHWM, the utility must choose to either purchase the
24759 power in excess of its RHWM from Bonneville at the "Tier 2" rate, supply the load with non-
24760 Federal power, or a combination of the two. Bonneville's Tier 2 rates recover the cost of
24761 incremental power that Bonneville purchases to serve customer-specific load growth.

24762 **3.7.2.8 Bonneville Wholesale Power Rates**

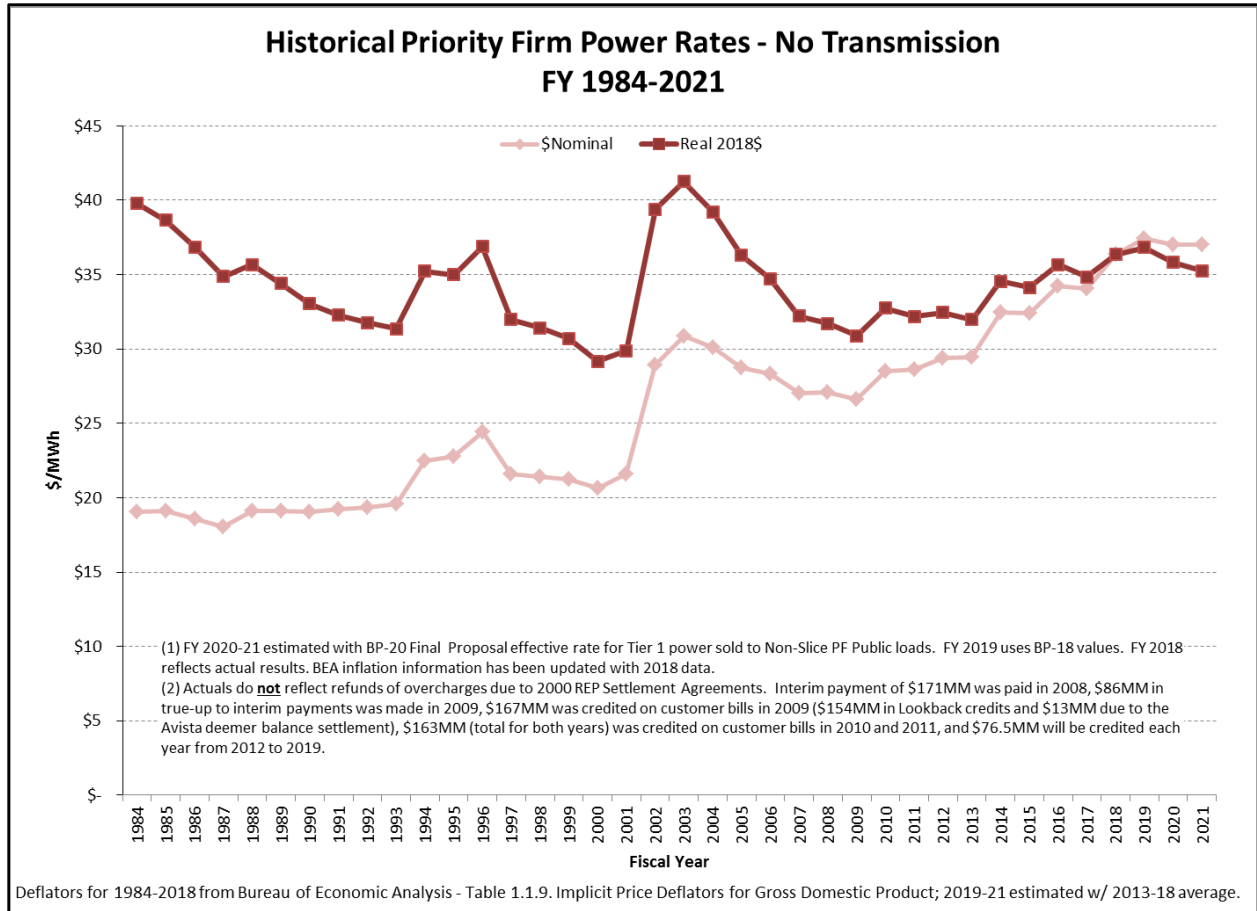
24763 The level of Bonneville's wholesale PF rate has ranged from below \$20 per MWh in the 1980s to
24764 the BP-20 average rate of \$35.59 per MWh, without accounting for inflation (Bonneville 2018a).
24765 In inflation-adjusted dollars, Bonneville rates have varied over time, but on average have
24766 remained within a relatively limited range (the "real 2018 dollars" in Figure 3-166 are adjusted
24767 for inflation).

24768 Established in 2019, BP-20 rates are as follows:

- 24769 • Average Tier 1 PF rate is \$35.62 per MWh.
- 24770 • Average Tier 2 PF rate is \$31.76 per MWh.

24771 Note that these are rates for Bonneville's sale of wholesale power to utilities, with Regional
24772 Dialogues power contracts. The rates these utilities charge their customers (i.e., retail rates to
24773 end users) are discussed below.

24774 Bonneville also sells surplus energy on regional wholesale electricity spot markets. From such
24775 sales Bonneville receives revenue, which is reflected as a credit (i.e., secondary energy credit) in
24776 Bonneville's rate making process to lower the PF rate. When setting rates, Bonneville forecasts
24777 its expected secondary energy credit for selling surplus power over a given rate period. This
24778 forecast does not guarantee that Bonneville will receive the estimated credit as actual prices
24779 for, and the supply of, surplus energy can fluctuate daily, if not hourly.



24780

24781 **Figure 3-166. Historical Bonneville Power Rates**

24782 Note: The two lines represent Bonneville power rates in nominal dollars (not accounting for inflation) and in real
24783 2018 dollars (adjusted for inflation).

24784 Source: Bonneville (2018c)

24785 **3.7.2.9 Transmission Rate Determination**

24786 Bonneville’s rates for transmission services are separate from those for the sale of power. Like
24787 power rates, however, transmission rates are established every 2 years in a rate case and are
24788 based on a transmission revenue requirement that includes capital-related costs and operating
24789 expenses determined in the Integrated Program Review. (Bonneville 2018c).

24790 **SEGMENTATION OF THE TRANSMISSION SYSTEM**

24791 “Segments” are a vital component of the Bonneville transmission ratemaking process.
24792 The ratemaking process involves a segmentation study that analyzes and classifies transmission
24793 facility investment (such as transmission lines and substation equipment) based on the function
24794 the facilities serve or the service the facilities are used to provide. The segments include:

- 24795 • **Network:** Core of the transmission system, which supports transmission of power from
24796 Federal and non-Federal generation sources or inerties.

- 24797 • **Southern Intertie:** Interregional transmission connection to California.
- 24798 • **Eastern Intertie:** Interregional transmission connection to Montana.
- 24799 • **Generation Integration:** Connection of Federal power generation to the transmission
24800 system.
- 24801 • **Ancillary Services:** Control and communication equipment to provide transmission system
24802 reliability services.
- 24803 • **Utility Delivery:** Low-voltage facilities associated with supplying power directly to utility
24804 distribution systems.
- 24805 • **Direct Service Industry Delivery:** Equipment used to step down transmission voltages to
24806 industrial voltages for DSI customers.

24807 Bonneville offers various forms of transmission service on the Network and Intertie segments of
24808 the transmission system. On the Network segment, Bonneville offers network integration (NT)
24809 and point-to-point (PTP) transmission service, along with the associated ancillary services.¹⁵
24810 In addition, Bonneville offers PTP transmission service (and ancillary services) on the Intertie
24811 segments. For PTP transmission service, Bonneville offers firm service (service that is reserved
24812 in advance and is the last service interrupted in the event of congestion on the system) on a
24813 long-term (longer than 12 months) or short-term (less than 12 months) basis. Bonneville also
24814 offers short-term non-firm service (scheduled and paid for on an as-available basis and subject
24815 to interruption before firm service if there is congestion).

24816 **TRANSMISSION REVENUE REQUIREMENT AND RATE CALCULATION**

24817 Bonneville sells transmission service on a wholesale basis. Through the transmission rate
24818 development process, rates are derived for the various services on the different segments of
24819 the transmission system. To derive the rates, each segment's share of the total transmission
24820 revenue requirement is identified based on the results of the segmentation study. In addition,
24821 transmission sales for the Network and the Intertie segments are forecast, along with revenues
24822 from sources other than sales of transmission service at general transmission rates. Revenue
24823 from other sources includes items such as fixed-price contracts, contracts that specify the rates
24824 for services, use-of-facilities contracts, and fixed-price fees. These revenues (referred to as
24825 "revenue credits") serve to offset a portion of the total revenue requirement for the
24826 appropriate segment(s). Based on the segmented revenue requirement and forecasted sales,
24827 transmission rates are calculated for each type of service that Bonneville offers on each
24828 segment.

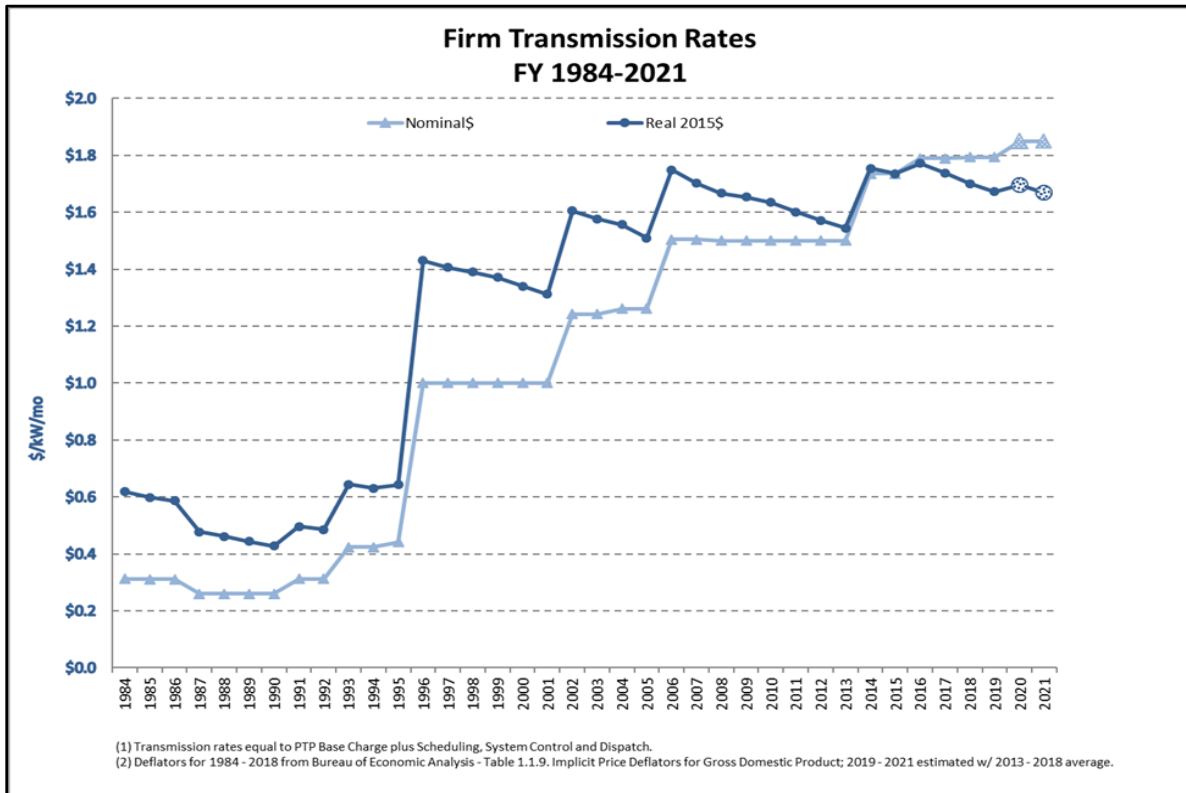
¹⁵ NT service allows for the delivery of energy from multiple resources to serve load under a single contract and requires Bonneville to plan for load growth over the course of the contract term. PTP service is for delivery of a specified amount of energy from one point on the system to another for a limited term. Ancillary services are services that are necessary to support the transmission of energy from resources to loads while maintaining reliability. These include contingency reserves, generation balancing reserves, frequency response, and voltage control

24829 **3.7.2.10 Bonneville Transmission Rates**

24830 For the BP-20 rate period (fiscal years 2020 and 2021), the rates for transmission service on the
24831 Network segment are:

- 24832 • \$1.771 per kilowatt (kW) per month for NT service.
- 24833 • \$1.533 per kW per month for long-term firm PTP service, and between \$0.050 and \$0.070
24834 per kW per day for short-term service depending on the length of service, with hourly
24835 service at 4.41 mills per kilowatt hour (kWh)

24836 The rate for long-term firm PTP service on the Southern Intertie is \$1.084 per kW per month.
24837 Rates for short-term Southern Intertie service are between \$0.036 and \$0.050 per kW per day,
24838 with hourly service at 9.98 mills per kWh. The rates for all of Bonneville’s other transmission
24839 services and the various ancillary services can be found in the BP-20 transmission rate
24840 schedules.¹⁶ Figure 3-167 depicts the rate for long-term transmission service on the Network
24841 segment from 1984 to present. The figure describes the trend with (real 2015 dollars) and
24842 without (nominal dollars) adjusting for inflation. A variety of factors affect the historical trend
24843 for transmission rates including the age of infrastructure, rate design, and rate case settlements
24844 (where rates are held to a certain level, based on settlement agreement with customers).



24845
24846 **Figure 3-167. Historical Firm Network Transmission Rates**

24847 Note: The two lines represent Bonneville transmission rates in nominal dollars (not accounting for inflation) and in
24848 real 2015 dollars (adjusted for inflation).

¹⁶ Reference Administrator’s Final Record of Decision, BP-20-A-03-AP03, Appendix C: 2020 Transmission, Ancillary, and Control Area Service Rate schedules and General Rate Schedule Provisions, published July 2019.

24849 **3.7.2.11 Regional Retail Electricity Rates**

24850 Retail electricity rates are the rates charged to individual end users, including residential,
24851 commercial, and industrial consumers. Retail rates vary by the type of utility and service. Retail
24852 rates typically are a “bundled” rate that reflect the cost of wholesale power, including the cost
24853 of the wholesale transmission of that power from the generator to the utility’s system,
24854 combined with the cost of the distribution system used to deliver the power to end users.

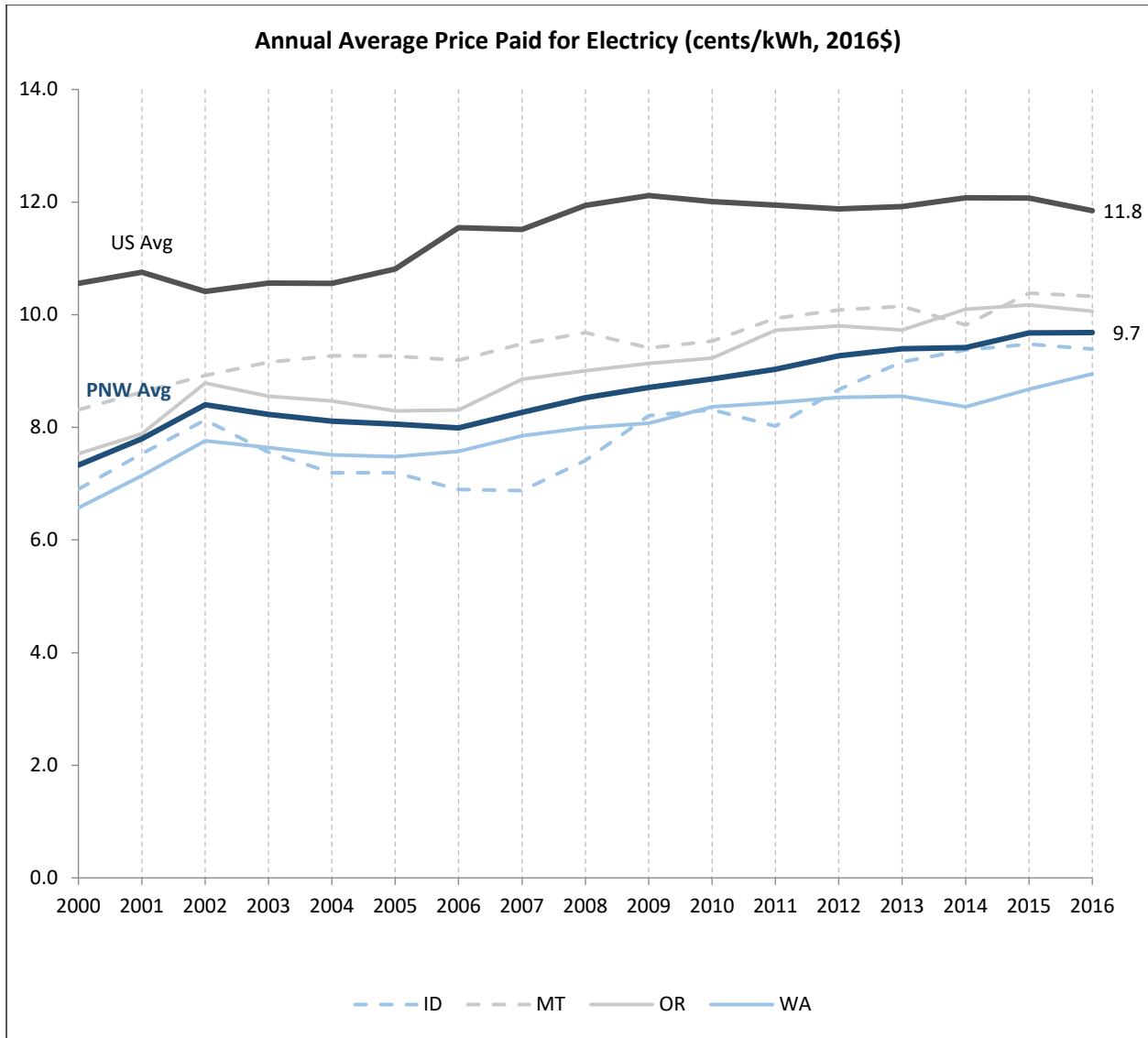
24855 Retail electricity rates in the Pacific Northwest have historically been among the lowest in the
24856 country (EIA 2017a).¹⁷ In 2016, across Pacific Northwest utilities, the average residential rate
24857 was 10 cents per kilowatt hour (kWh) (EIA 2017c). On average, the electricity cost per kWh in
24858 the Pacific Northwest is 2 cents lower (22 percent lower) than the national average. As of 2016,
24859 Washington had the lowest overall electricity rate in the nation. On average, commercial end
24860 users across the Pacific Northwest pay between 8.57 and 10.12 cents per kWh compared to a
24861 national average of 10.66 cents per kWh. Similarly, industrial end users in the region pay
24862 between 4.6 and 6.66 cents per kWh, below the national average of 6.88 cents per kWh.¹⁸

24863 In the Pacific Northwest, average residential electricity bills range from \$88.95 to \$96.71 per
24864 month, which is roughly \$20 lower (21 percent) than the national average of \$112.59 (EIA
24865 2017c).¹⁹ As a percentage of income, residents in the Pacific Northwest spend 2.1 percent of
24866 median income on electricity. However, there are several locations in the Pacific Northwest
24867 where expenditures on electricity are as high as 5.1 percent of median household income,
24868 making these areas and their associated low-income populations more vulnerable to fluctuating
24869 electricity prices. An analysis of regional residential electricity rates in 2016 by the NW Council
24870 found that rural utility customers consume and spend more on electricity than urban
24871 customers. The higher consumption in rural areas results from widespread electric heating, low
24872 electricity prices, and a generally lower adoption rate of energy efficiency measures. With
24873 higher average spending and lower average incomes, the percentage of rural income spent on
24874 electricity is considerably higher.

¹⁷ During and following World War II, relatively low electricity prices in the Pacific Northwest helped drive aluminum smelting as a primary industry in the region representing 6 to 7 percent of global capacity and 40 percent of U.S. capacity (NW Council 2018c). Due to increasing costs and a globalizing marketplace, many of the aluminum companies failed during the West Coast energy crisis in 2001 (NW Council 2018c). Nonetheless, low electricity costs, along with carbon-free energy and easy access to trans-Pacific telecommunications networks, continue to attract commercial and industrial businesses. The Pacific Northwest is particularly attractive to energy-intensive industries such as cryptocurrency-mining operations and data centers (NW Council 2018). The NPCC measured load from cryptocurrency mining activities at an estimated 20 to 30 aMW for 2017 based on a survey of regional utilities (NW Council 2018b). Companies such as Apple, Facebook, Amazon, and Microsoft are driving continued growth in regional data centers (NW Council 2018b).

¹⁸ Due to the level of geographic specificity available within electricity data, this discussion of regional electricity rates focuses primarily on all of Oregon, Washington, Idaho, and Montana unless otherwise noted. Figures 3-45 to 3-48 capture the Bonneville service area, which includes small portions of additional states.

¹⁹ Average residential electricity consumption varies from a low in Montana of 813 kWh per month to a high of 955 kWh in Washington, compared to a national average of 897 kWh per month.

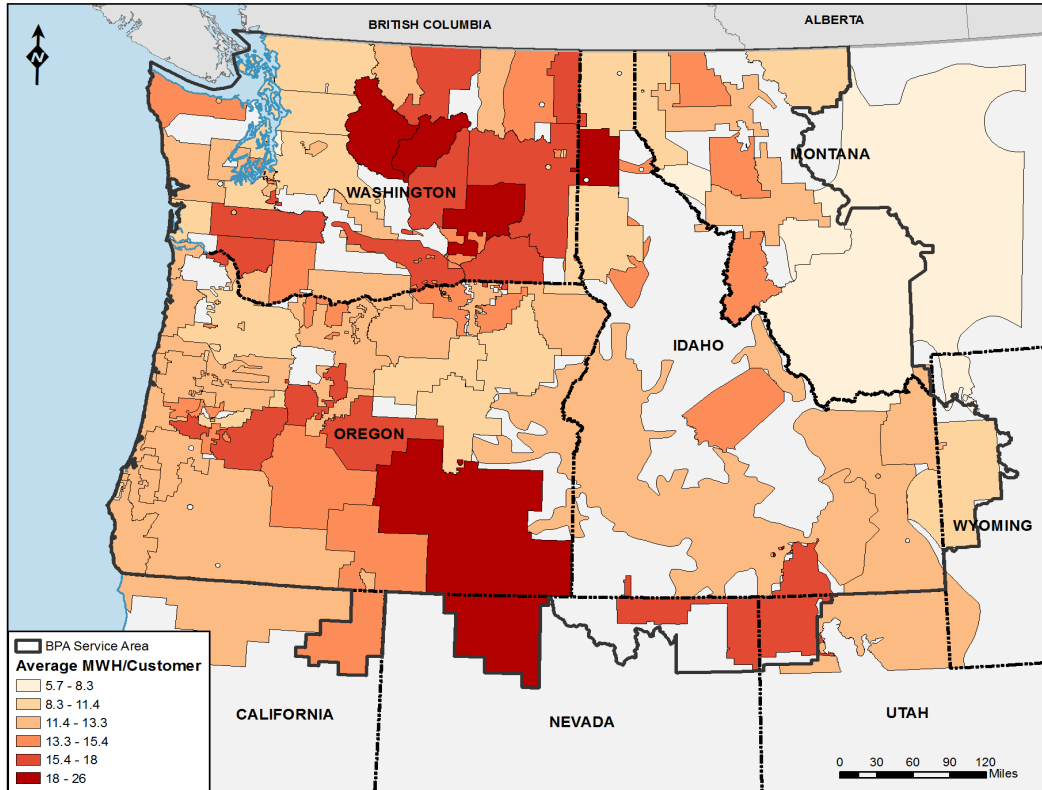


24875
 24876 **Figure 3-168. Annual Average Retail Price Paid for Residential Electricity by State and the**
 24877 **National Average, 2000 to 2016**

24878 Note: Because of the geographic breakdown of the data source, the Pacific Northwest average includes all of
 24879 Idaho, Oregon, Washington, and Montana.
 24880 Source: EIA (2017c)

24881 Figure 3-169, Figure 3-170, Figure 3-171, and Figure 3-172 illustrate electricity rates for the
 24882 residential sector, median household income levels by county, and average consumption by
 24883 utility area.²⁰ Expenditures are up to 5 percent of income in some of the more rural counties
 24884 and are generally below 1.5 percent of income in the most densely populated urban counties.

²⁰ Consumption by utility is derived from EIA utility data and represents a ratio of total residential electricity consumption and the total number of residential customers for each utility.



24885

24886

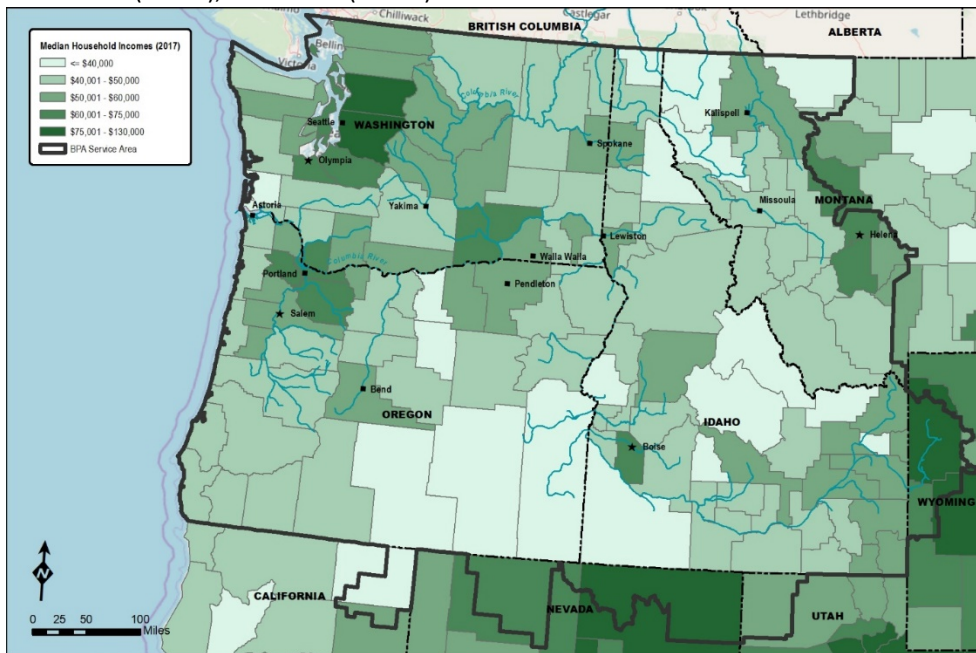
Figure 3-169. Residential Electricity Consumption

24887

Note: The boundary of the region shown is the Bonneville service area.

24888

Source: EIA (2017c), Bonneville (2018b)



24889

24890

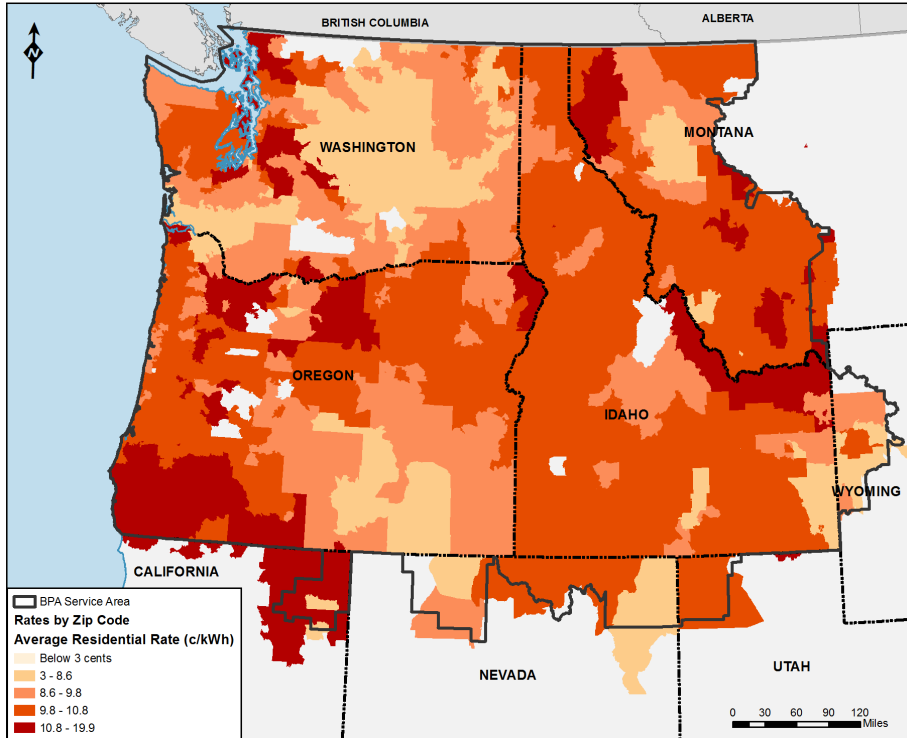
Figure 3-170. Median Household Income

24891

Note: The boundary of the region shown is the Bonneville service area.

24892

Source: Census (2017a)



24893

Figure 3-171. Residential Electricity Rates

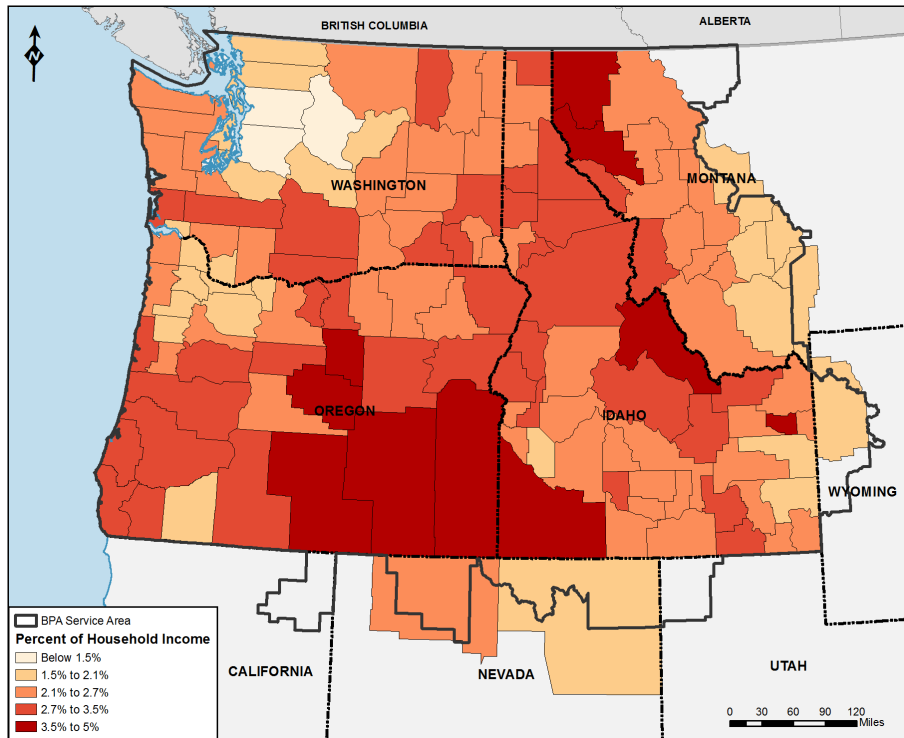
24894

Note: The boundary of the region shown is the Bonneville service area.

24895

Source: U.S. Department of Energy (DOE) and National Renewable Energy Laboratory (NREL) (2018)

24896



24897

Figure 3-172. Electricity Expenditures per Household

24898

Note: The boundary of the region shown is the Bonneville service area.

24899

Source: Bonneville (2018b), Census (2018); EIA (2017c)

24900

24901 **3.7.3 Environmental Consequences**

24902 This section evaluates effects of the No Action Alternative and the MOs on power generation,
24903 power and transmission system reliability, power flows across the transmission system,
24904 electricity rate pressures, and the cost of living and doing business in the Pacific Northwest.
24905 A summary comparing the effects of the No Action Alternative and the MOs is included in
24906 Section 1.3 of Appendix H, *Power and Transmission*. Chapter 7, *Preferred Alternative*, describes
24907 the power generation and transmission effects associated with the Preferred Alternative.

24908 **3.7.3.1 Base Case Methodology and Cost Sensitivities Analysis²¹**

24909 The future of power generation and transmission across the Pacific Northwest is subject to
24910 uncertainty, even under the No Action Alternative, due to evolving policy (e.g., emissions
24911 reductions targets), environmental factors (e.g., climate change) and technological growth.
24912 In order to evaluate the potential effects of the MOs against the No Action Alternative, the
24913 power generation and transmission analysis requires a common set of assumptions regarding
24914 these factors. These common assumptions, as identified throughout the methodology and
24915 results discussion, form the “base case” for the analysis. With respect to key uncertainties, the
24916 analysis employs alternative scenarios to produce a reasonable range of potential effects of the
24917 MOs, as described in the Base Case Methodology section, below.

24918 Not all key uncertainties influencing the analysis are accounted for in the base case, therefore
24919 the analysis provides additional sensitivity analysis and other regional cost pressure describing
24920 the sensitivity of the power and transmission rate pressure effects to alternative assumptions.
24921 For example, a key factor influencing the overall power generation and transmission effects
24922 analysis that is not reflected in the base case analysis is the potential extent of future coal plant
24923 retirements. The base case assumptions regarding future coal capacity developed for this
24924 analysis in 2017 do not account for new and emerging information on additional coal
24925 retirements since that time. The analysis of each MO therefore first provides base case analysis
24926 results, followed by the information resulting from the additional sensitivity analyses and other
24927 regional cost pressure.

24928 **BASE CASE METHODOLOGY**

24929 This analysis assesses changes to power generation that would result from the MOs to inform
24930 Bonneville’s ability to supply adequate and reliable power to its firm power customers under
24931 long-term contracts. The analysis considers whether the MOs would result in the need for
24932 Bonneville or other regional entities (i.e., wholesale customers who might be receiving less
24933 power from Bonneville under an alternative) to acquire power from resources (e.g., new
24934 generating plants) and/or construct new transmission infrastructure to replace lost capability at
24935 Federal hydro projects. To the extent this analysis identifies potential needs to acquire
24936 resources or construct transmission infrastructure, and if Bonneville proposes to take such

²¹ The rates analysis included in this CRSO study are used for comparison purposes specific to this EIS and are not equal to current or forecast actual rates.

24937 action in the future, Bonneville would do so consistent with the Northwest Power Act and
24938 complete additional site-specific planning, analysis, and compliance with environmental laws
24939 including NEPA.

24940 To the extent that the MOs increase the cost of power generation and transmission (e.g., if
24941 Bonneville or other entities need to acquire new sources of power or construct transmission
24942 infrastructure), the increased costs would place upward pressure on wholesale and retail
24943 electricity rates. The term “upward rate pressure” indicates the potential for increases in rates
24944 resulting from the added costs of generating and transmitting power; upward rate pressure
24945 could lead to increased rates absent the ability of Bonneville or other entities to balance out
24946 the added costs. Likewise, “downward rate pressure” indicates the potential for reductions in
24947 rates resulting from decreased costs of generating and transmitting power.

24948 The power and transmission analysis characterizes effects as beneficial or adverse (or no effect,
24949 where relevant), considering the following:

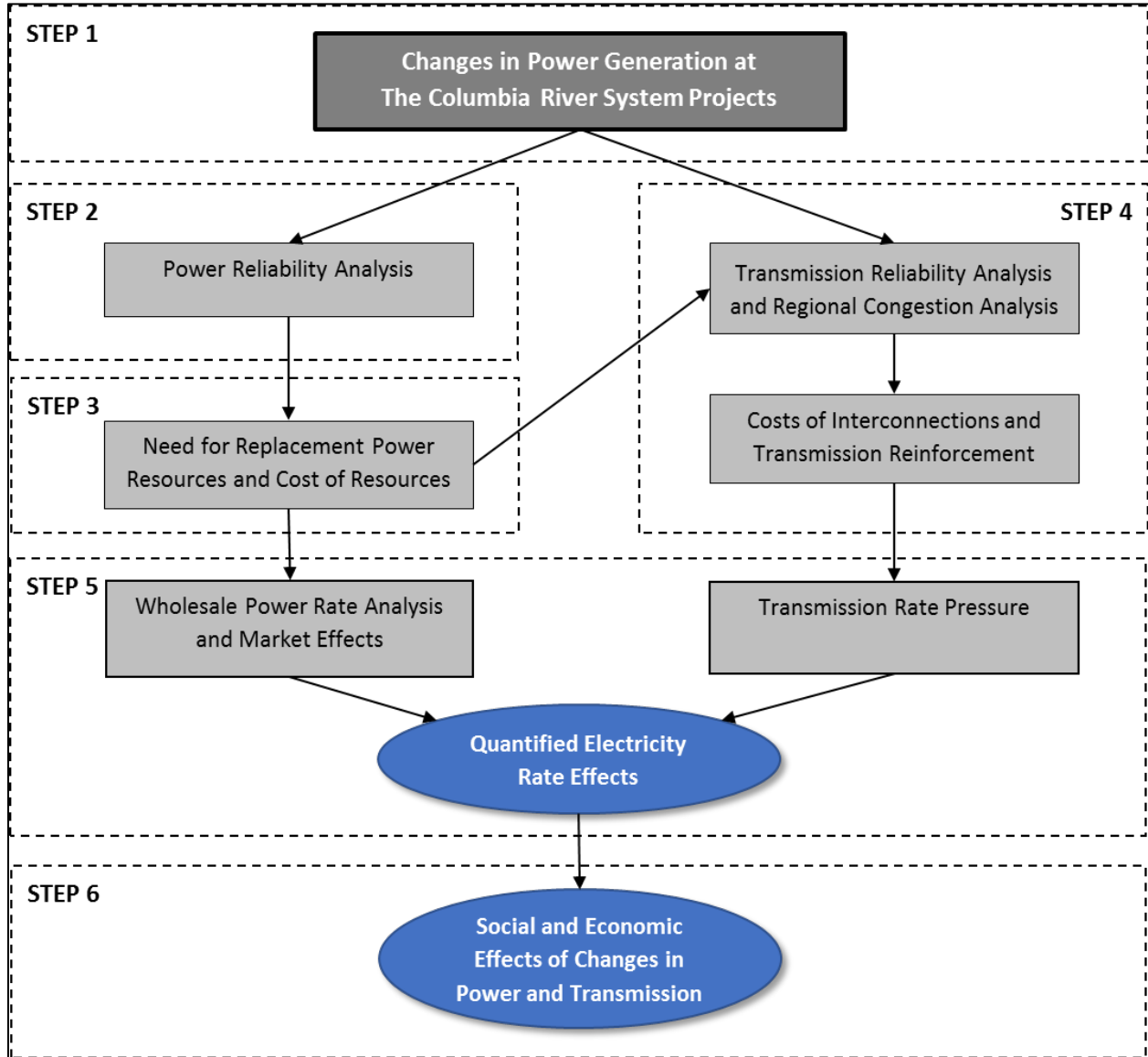
- 24950 • Geographic scope of the effect or the size of the population affected. Because of the
24951 interconnected nature of the Pacific Northwest electricity system, changes at one or a
24952 subset of CRS projects may affect retail ratepayers more broadly across the Pacific
24953 Northwest.
- 24954 • Relative magnitude of the effect. The intensity of the power and transmission effects refers
24955 to the scale of changes in power generation; transmission flows; wholesale power and
24956 transmission rates relative to historical levels; and to the costs of living and doing business
24957 for residential, commercial, and industrial retail consumers of electricity.
- 24958 • How an effect persists over time. An effect may be moderate in the short term (e.g., limited
24959 to a construction period), but have negligible or no effect over the long term (e.g., beyond
24960 the construction period). Most rate pressure effects are long term in this analysis.

24961 The power and transmission socioeconomic analysis considers the effects of the MOs over a 50-
24962 year timeframe. However, the quantitative analysis is limited to the period for which
24963 information is available to reasonably predict potential effects. The social welfare effects are
24964 average annual values of changes in the marginal cost of producing power. These average
24965 annual estimates are subject to increasing uncertainty over the 50-year timeframe of the
24966 analysis making the analysis difficult on a 50-year timeframe. Therefore, the quantitative
24967 regional economic effects are reflected through changes in rate pressure for residential,
24968 commercial, and industrial ratepayers over a 20-year timeframe (2022 to 2041), with a
24969 qualitative assessment of whether and how effects may persist beyond that timeframe.²²
24970 Quantifying effects beyond this timeframe would be speculative due to the considerable

²² The power analysis models a single year (2022) using 80 historical water years under the operations and management regime for the CRS projects defined by the MOs. The transmission power-flow analysis relies on the 2023 and 2028 WECC base cases to inform the transmission system reliability assessment and the 2028 WECC base case is used to inform the regional transmission congestion forecasts. The transmission rate analysis models the cumulative rate pressure differences through the 2028 rate period (fiscal year 2028–2029). The socioeconomic analysis then relies on the rate forecast from the NW Council to project the effects over the 20-year timeframe.

24971 uncertainty regarding how the electricity sector will evolve in response to recent and emerging
 24972 policies (particularly as relates to GHG emissions standards and legislation, as described in
 24973 Section 3.7) and potential technological growth (e.g., batteries).

24974 Figure 3-173 provides a high-level overview and depiction of the analytical framework. Note
 24975 that multiple components of the analysis occur within each of the boxes depicted in the figure.
 24976 Additional detailed methodological information is described further in the step descriptions
 24977 below and in Appendix H, *Power and Transmission*.



24978 **Figure 3-173. Power and Transmission Analytical Framework**
 24979 Note: Additional power and transmission analysis occurs within each of the step boxes depicted.
 24980

24981 The stepwise methodology for the power and transmission analysis is as follows:

24982 **Step 1: Estimate Changes in Power Generation.**

24983 The first step estimates power generation from the CRS and other major non-Federal hydropower
24984 projects in the region. The Bonneville hydropower simulation model (HYDSIM) model calculates
24985 power generation and analyzes that output in 80 different flow years at each of the 14 CRS
24986 projects.^{23,24} Non-Federal projects on the Columbia are relevant because the timing and volume of
24987 flow from the CRS projects would alter downstream hydroelectric generation and affect their
24988 overall hydropower output. This step also examines changes to generation under dry conditions.
24989 Appendix I, *Hydroregulation*, and Appendix H, *Hydropower*, provide more detailed
24990 methodological information for this step.

24991 **Step 2: Analyze Effects on Power System Reliability.**

24992 This step considers whether the region has enough power capacity and energy to meet
24993 consumer demand (i.e., load). Synthesizing HYDSIM hydropower generation outputs with NW
24994 Council load-and-resource forecasts and power-import assumptions, the GENeration Evaluation
24995 SYStem (GENESYS) model simulates regional power generation and demand to determine
24996 power system reliability. This step estimates the effect of the MOs on power system reliability
24997 (i.e., LOLP). If an MO reduces power system reliability relative to the No Action Alternative
24998 (i.e., if there is an increase in LOLP), then the analysis continues to Step 3; otherwise, it
24999 progresses directly to Step 4.

25000 **Step 3: Determine Need for Potential Replacement Resources and Associated Costs.**

25001 This step identifies additional resources necessary to ensure the Federal power system is able
25002 to meet the Administrator's obligations, maintains its power system reliability, and recovers the
25003 associated costs of those resources. As described above in Section 3.7.2.9, Bonneville is
25004 currently selling firm power through September 2028 under long-term Regional Dialogue power
25005 sales contracts. As previously described, under these contracts if a wholesale customer's load
25006 exceeds the RHW, the customer either has Bonneville supply the additional power needed,
25007 relies on non-Federal power, or a combination of the two (1) to have Bonneville supply the
25008 incremental amount of firm power needed, (2) to use non-Federal power, or (3) to have
25009 Bonneville supply part and non-Federal power to supply part of the required amount to serve
25010 its load. The contract and Bonneville's current priority firm power rate design (the TRM) is
25011 based on the Tier 1 system firm critical output, which is the amount of firm power produced by
25012 the Federal hydroelectric dams, Columbia Generating Station, and the output of the non-
25013 Federal resources Bonneville has acquired to meet its firm power supply contractual
25014 obligations.

²³ Although the focus of this chapter is on the CRS projects, HYDSIM analyzes the full set of Federal and non-Federal projects. Results for CRS and non-CRS projects are documented in Appendix J, *Hydropower*.

²⁴ Changes in hydropower generation at Grand Coulee affect the Colville payment. Section 3.7.4 and Appendix H, *Power and Transmission*, describe the change in the payment. Appendix J describes generation changes.

25015 In the event the Tier 1 system firm critical output decreases, the resulting reduction in system
25016 capability can lead to a change in each customer's RHW, and an increase in its load above the
25017 Tier 1 system's ability to supply. This increases the customer above-high-water-mark load,
25018 increasing the amounts of power which either Bonneville or the customer is obligated to
25019 acquire to meet that load. This step in the analysis identifies what resources might be
25020 purchased or acquired and quantifies the cost of maintaining the baseline LOLP for the system.
25021 The specific resources that would be developed to maintain a sufficient and reliable supply of
25022 power, and how the costs of those resources would be allocated to Bonneville's power rates,
25023 are uncertain. To reflect this uncertainty, the analysis considers a range of potential outcomes
25024 as follows:

25025 • **Potential Resource-Replacement Portfolios:** This analysis considers two resource-
25026 replacement portfolios to maintain a sufficient and reliable power supply.
25027 The "conventional least-cost" portfolio chooses the traditional least-cost resources
25028 (i.e., least-cost gas-fired resources). The "zero-carbon" portfolio selects the lowest-cost
25029 carbon-free resources (e.g., solar, wind, or non-generating tools such as demand
25030 response).²⁵

25031 Recent studies by other organizations also examined resource options for replacing
25032 resources in the region. .

25033 A 2017 report released by E3 (2017), assessed the resource options for the northwest if
25034 resources with high GHG-emissions profiles are replaced with new resources with the goal
25035 of deep decarbonization in the Northwest, evaluating various policy options for their
25036 effectiveness at reducing GHG emissions and their cost. While the report cannot be directly
25037 compared to the CRSO EIS, a key finding in the E3 study is that for achieving 80 percent
25038 carbon reduction in the Northwest, the least-cost approach is not a 100% carbon free
25039 portfolio with new renewable resources but instead consists of a combination of energy
25040 efficiency, renewables, and natural gas. The EIS assesses replacing lost hydropower in the
25041 MOs with the zero-carbon replacement resources on the assumption that *new* resources
25042 would be carbon-free. Existing resources (other than coal-plants slated for retirement)
25043 would continue to operate and may decrease or increase generation in response to changes
25044 in hydropower generation from the CRS projects and non-Federal hydropower projects in
25045 the Columbia River basin.

25046 In March 2018, the NW Energy Coalition (NVEC) released a report prepared by Energy
25047 Strategies Inc. that evaluated the effects of replacing the LSR projects' output using a
25048 combination of demand response, conservation measures, utility-scale solar and wind
25049 generation, and natural gas. The basic approach of this study was similar to that of the EIS
25050 for identifying both a potential least-cost and a potential zero-carbon portfolio for replacing
25051 lost hydropower. The NVEC study results were considered in testing the outputs of the EIS
25052 analysis. (Section 3.7.3.5 and Appendix H describe the NVEC and compare its results with
25053 the EIS analysis in more detail.)

²⁵ Cost-effective conservation is already included in the No Action Alternative.

25054 This step in the EIS for identifying potential portfolios of replacement resources does not
25055 take into account the process for making decisions about replacement resources and
25056 acquiring these resources. First, Bonneville and other regional entities would have to decide
25057 who is responsible for acquiring the replacement resources. Second, if Bonneville is
25058 responsible for acquiring the resource(s), Bonneville would likely need to engage in a
25059 lengthy statutory process to acquire that resource.²⁶ Once these decisions have been made
25060 and requirements satisfied, long lead times— potentially a decade—may be required for
25061 the planning, permitting, land-acquisition, and physical construction of new generation
25062 (e.g., gas, solar, wind, or pumped storage) and new transmission lines.

25063 This step also does not address the additional generation that may be needed to supply
25064 balancing reserves to reliably integrate a large amount of new intermittent renewable
25065 resources under the zero-carbon portfolio. Generation balancing reserves allow
25066 transmission grid operators to adjust the amount of generation in response to changes
25067 in load and generation in order to balance load and generation levels and maintain
25068 transmission system reliability. The generation output of most new renewable resources
25069 is “intermittent” (more variable, e.g., subject to sudden changes in the weather) than
25070 dispatchable resources and requires greater amounts of generation balancing reserves
25071 to balance the fluctuations in generation levels. In the base analysis modeling, the
25072 generation balancing reserves needed for each MO are kept the same as the No Action
25073 Alternative. This assumption reflects the uncertainty regarding whether additional
25074 generation balancing reserves might be needed to integrate renewable resources. In the
25075 absence of a full evaluation of the need for reserves, this analysis provides additional
25076 information on the estimated value of needed reserves.

25077 Cost estimates for the potential replacement resource portfolios are based on the NW
25078 Council’s Seventh Power Plan and Mid-Term Assessment. Annual capital costs described
25079 for replacement resources reflect insurance costs, operations and maintenance costs,
25080 and debt and interest payments over a repayment period of 30 years.

25081 • **Financing Portfolios:** The effects of acquiring replacement resources on wholesale and
25082 retail rate pressures differ depending on the resource-replacement portfolio chosen and
25083 what entity acquires them.²⁷ This analysis modeled two resource-replacement portfolios

²⁶ Section 3(1) of the Northwest Power Act states that the Bonneville Administrator is not authorized to construct, or have ownership of, any electric generating facility. 16 U.S.C. § 389a(1). Bonneville’s acquisition of resources is controlled by section 6 of the Northwest Power Act; acquiring a resource with planned capability over 50aMW and for a period of more than 5 years requires the Administrator to follow the procedures set forth in section 6(c). See 16 U.S.C. § 839d(c). Storage and battery technologies are not resources under Section 6.

²⁷ Bonneville’s Regional Dialogue contracts with the utilities in the Northwest expire in 2028. These contracts are Northwest Power Act Section 5(b) (16 USC 839c(b)) firm power sales, which guarantee firm power supply. Public utilities and Federal agencies currently have the right to receive such service under their Regional Dialogue power sales contracts. Under alternatives and scenarios that require resource additions for the region, whether it is due to a loss of hydropower generation, load growth, or other causes such as coal plant retirements, Bonneville could find itself in the position of acquiring resources to meet its firm power obligations under section 5(b) of the Northwest Power Act, which might be compounded by a loss of Federal system capability due to the outcome of the CRSO EIS.

25084 that consider two cost streams for financing the development of these resources. These
25085 alternative portfolios affect costs because ownership or rights to the capacity of resources
25086 affects how costs would be distributed across ratepayers in the region. One portfolio
25087 assumes Bonneville would acquire output from the replacement resources (costs recovered
25088 from Bonneville's customers and, ultimately, regional retail ratepayers). The second
25089 portfolio assumes regional public utilities would finance the construction of resources, and
25090 their costs would be recovered directly from the retail ratepayers of those utilities.²⁸ The
25091 discussion of social and economic effects below examines the rate effects (i.e., extent of
25092 upward or downward rate pressure) of various options depending on whether Bonneville or
25093 other entities take the lead in acquiring the needed resources. It also addresses the fact that
25094 different customers would be affected differently depending on these financing options and
25095 by what utility provides their power. Regional utilities that purchase most or all of their
25096 power from Bonneville would experience larger effects than IOUs or other public utilities
25097 that do not purchase Bonneville power directly. Appendix H, Power and Transmission,
25098 provides additional discussion of these issues.

25099 **Step 4: Analyze Effects on Transmission System Reliability, Congestion, and the Need for**
25100 **Infrastructure.**

25101 The Bonneville transmission system analysis relies on power-flow models to assess changes to
25102 the flow of electricity on the transmission system under each alternative, including the need for
25103 new transmission infrastructure to address any identified system limitations. Because the
25104 transmission system is planned to reliably operate during times of peak loading, performance
25105 (and the need to reinforce the system to maintain reliable transmission operation) is analyzed
25106 during seasonal peak loading times within the region. Replacement resource assumptions
25107 (including quantities and general locations) developed under Step 3 were incorporated into the
25108 powerflow models to compare the MOs with the No Action Alternative. If the analysis indicated
25109 that reinforcement of the system would be necessary with any of the MOs, a transmission
25110 network reinforcement to address the identified system limitations was developed and the cost
25111 was estimated. Based on the potential replacement resource portfolios identified in Step 3, the
25112 analysis also identifies potential additional facilities that would be necessary to interconnect
25113 replacement resources to the transmission system associated costs. The developer of the
25114 resources identified in Step 3 may have to develop additional transmission infrastructure in
25115 order to connect resources to the larger transmission network. The costs of the additional
25116 transmission infrastructure would vary depending on the geographical location of the resource
25117 with respect to the transmission network, size of the individual project, and other factors.

25118 In addition, the GridView model produces an hourly-congestion forecast for the regional
25119 transmission grid over an entire year (8,760 total hours).²⁹ This regional congestion forecast

²⁸ These costs are marginally higher in the conventional least-cost portfolios when Bonneville finances because the analysis assumes that Bonneville would continue using critical water year in rate making procedures. Under critical water year conditions more fuel would be used resulting in higher estimated costs. Both portfolios use the Bonneville FY 2019 tax-exempt borrowing 30-year rate for financing.

²⁹ The GridView model is a production cost model that analyzes the hour-to-hour operation of the transmission system. The production cost model conforms to the operating constraints of both the generators themselves and

25120 presents and compares the number of congested hours (as defined for this assessment as the
25121 transmission path being within 0.1 percent of its current transfer limit³⁰) at certain locations on
25122 the transmission system³¹ for each alternative under three water-flow portfolios (high, median,
25123 and low). The congestion analysis uses a 2028 base case³² that assumes that other generating
25124 resources would be used or dispatched in order based on variable cost (i.e., the least-cost
25125 resources would be used to produce power before more costly resources were used) to offset
25126 hydropower generation changes under each of the MOs. This includes an assumption that coal-
25127 fired, natural-gas-fired, and nuclear generators across the Western Interconnection that had
25128 not formally announced retirement dates of 2028 or earlier at the time this base case was
25129 created would be available for dispatch.

25130 **Step 5: Quantify Effects on Electricity Rates.**

25131 This step translates the effects identified in Steps 3 and 4 into rate pressure for Bonneville's
25132 wholesale power and transmission rates, and the resulting effects on retail rates for end users
25133 across the region. Specifically, Step 5 evaluates the MOs' impacts on electricity rates by
25134 assessing the effect on (1) Bonneville's wholesale power rate pressure; (2) Bonneville's
25135 wholesale transmission rate pressure; (3) regional retail rate pressures; and (4) Bonneville's
25136 cash flows (i.e., financial analysis).

25137 The analysis of Bonneville's wholesale rates considers multiple variables: (1) the level of
25138 generation from the CRS projects and the costs of replacement resources (for either the
25139 Bonneville or region financing portfolio), including costs of any new transmission infrastructure;
25140 (2) amount of secondary surplus power sales (i.e., the amount of surplus power available for
25141 Bonneville to sell in the market) and purchases, as well as changes in transmission sales; and
25142 (3) the costs of structural and operational measures relevant to the MOs.

25143 **Power Rate Pressures**

25144 The rates analysis relies on the AURORA model to generate estimates of how much power can
25145 be sold into the wholesale market (market sales/purchases in total MWh) and the market price
25146 (\$ per MWh).³³ Because Bonneville is an actor in the broader regional electricity market, market

of the transmission system within the Western Interconnection to determine power flows across an economically optimized (i.e., using conventional least cost to operate) system.

³⁰ Path and flowgate transfer limits can be affected by the availability of generation (both real power and reactive power). However, in the CRSO transmission congestion analysis, the path and flowgate transfer limits were assumed to remain constant. The Gridview modeling completed did not identify if a change in resources in the different alternatives would change interface definitions or ratings associated with the addition of replacement resources.

³¹ The portions of the transmission system monitored (i.e., transmission interfaces) include Bonneville Network flowgates, WECC-rated paths, and combinations of flows on multiple parallel paths. Some transmission lines are, therefore, part of more than one interface monitored for congestion.

³² Using the WECC 2028 Anchor Data Set Version 2.2 base case.

³³ AURORA is a production cost model that uses loads and resource projections to calculate wholesale markets for the West. The model estimates how much power can be sold into the wholesale market and estimates the related prices. Appendix I, *Hydroregulation*, and Appendix J, *Hydropower*, provide detailed information on this model.

25147 prices are sensitive to fluctuations in Bonneville’s sales and purchases. Thus, this analysis
25148 quantifies effects on regional utilities that purchase power from the market. It also accounts for
25149 effects on the extent to which utilities export power outside of the region (i.e., across the
25150 Western Interconnection).³⁴

25151 The base case effects on Bonneville’s wholesale power rates are provided in each MO under the
25152 section heading Bonneville Wholesale Power Rates. The rate pressure effects are provided in
25153 two tables for each MO. The first table (“Change in Bonneville’s Priority Firm Tier 1 Rate,
25154 Bonneville Finances”) reflects the extent of rate pressure on Bonneville’s wholesale power rates
25155 assuming Bonneville acquires resources to replace the generating capability lost due to the
25156 respective MO. The second table (“Change in Bonneville’s Priority Firm Tier 1 Rate, Region
25157 Finances”) reflects the extent of rate pressure on Bonneville’s wholesale power rates assuming
25158 regional customers acquire resources to replace lost capability. The tables include the
25159 wholesale power rate pressure effects for both resource replacement portfolio options (zero-
25160 carbon portfolio and conventional least-cost portfolio) described in Step 3 against the No
25161 Action Alternative (NAA).

25162 An example of the “Bonneville Finances” table is provided below.

Change in Bonneville's Priority Firm Tier 1 Rate, Region Finances				
	Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
	\$ rate pressure	change from NAA	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)				
Base Rate	\$/MWh	\$/MWh	\$/MWh	\$/MWh
Change from NAA due to Costs	\$	%	\$	%
Change from NAA due to Load		%		%
Total Base Change in Rate		%		%

25163

25164 ***Wholesale Transmission Rate Pressures***

25165 The analysis of wholesale transmission rates calculates the change in transmission rate pressure
25166 based on capital costs of generator interconnections, transmission system reliability projects,
25167 and effects in transmission sales,³⁵ which include the impact of market prices and hydropower
25168 generation changes. These rate pressure changes reflect the difference between rate pressures
25169 under the MOs as compared with the No Action Alternative.

25170 For the socioeconomic analysis, the transmission rate pressure is not applied directly to
25171 Bonneville transmission rates but to regional retail electricity rates based on the historical
25172 portion of retail rates stemming from the utility transmission costs. The socioeconomic analysis
25173 uses the BP-20 transmission customer impact model to distribute the rate pressure

³⁴ The Western Interconnection encompasses all or most of the states of Oregon, Washington, California, Nevada, Arizona, New Mexico, Wyoming, Idaho, Montana, Utah, and Colorado, and portions of South Dakota and Texas.

³⁵ Sales assume that existing transmission service would be utilized prior to additional sales occurring. Each replacement resource type would have different transmission usage rates, resulting in differing sales; under the solar replacement resources, additional sales were calculated for each of the MOs.

25174 geographically. This approach assumes there will not be changes in the type or amount of
25175 service taken, the location of additional sales, or changes in Bonneville transmission customers
25176 that would impact the geographic distribution. The analysis estimates the effective rate
25177 pressure by customer by applying each customer's percent of the overall rate change from BP-
25178 20 rates, with any potential service conversion adjustments, to the rate pressure change. This
25179 estimate of rate pressure paired with the customer's geographic region provided the input for
25180 the geographic rate pressure analysis in the socioeconomic analysis. Additional information
25181 regarding sales assumptions used for the transmission rate pressure analysis is included in
25182 Appendix H, *Power and Transmission*.

25183 **Retail Rate Pressures**

25184 The effects of the MOs on retail rate pressure (*i.e.*, for rates charged by retail utilities, not
25185 Bonneville) would be influenced by changes in Bonneville's wholesale power and transmission
25186 rates, as well as changes in market-power purchases. For each MO, the analysis integrates the
25187 following elements to evaluate retail rate pressure:

- 25188 • **Bonneville Power Rate Pressure:** For Bonneville's power customers, changes in wholesale
25189 power rates directly affect utility expenditures for the amount of load they serve with
25190 Federal power purchased from Bonneville. To estimate the effect on retail rate pressure,
25191 the analysis spreads this change in expenditures over total utility load.
- 25192 • **Bonneville Transmission Rate Pressure:** The analysis first utilizes utility-level data compiled
25193 by EIA to identify the share of the "bundled" retail rate that is attributable to the costs of
25194 transmission service (EIA 2016, EIA 2019). The analysis then increases that share over time
25195 based on the transmission rate pressure estimates that would occur under each MO. The
25196 retail rates analysis does not utilize Bonneville-specific transmission rates, instead relying on
25197 historical retail rates data to calculate county-level effects based on the transmission rate
25198 pressure.
- 25199 • **Market Purchases:** For all utilities in the region (*i.e.*, Bonneville, its power customers, and
25200 non-Bonneville customers), the analysis estimates how potential changes in market power
25201 prices and purchases (from AURORA) would affect overall utility expenditures. The analysis
25202 then spreads these changes over total load to estimate retail rate pressure.
- 25203 • **Changes in Regional Power Production Costs:** For all private IOUs in the region, the analysis
25204 estimates the change in variable costs (from the AURORA model) from existing natural gas
25205 and coal resources. The rates analysis allocates the change variable costs from these
25206 resources and spreads them over IOU total load to estimate implications on retail rates.

25207 **Bonneville Financial Analysis**

25208 Included in each MO are the results of a net present value (NPV) calculation of Bonneville's
25209 expected future cash flows. The purpose of the financial analysis is to enable comparisons
25210 between alternative investment opportunities. The financial analysis quantifies the expected
25211 stream of cash inflows and outflows over time and then discounts those cash flows over time to
25212 produce a single value representing how much an investment is worth at a specific point in

25213 time. Discounting accounts for the time-value of money; a dollar received today is worth more
25214 than a dollar received in 10 years. Present value calculations are therefore sensitive to the
25215 discount rate used. The Bonneville financial analysis relies on an official agency risk-adjusted
25216 discount rate of 7.9 percent.³⁶

25217 The financial analysis includes only those cash flows that differ between the various MOs and
25218 the No Action Alternative. Ultimately, these cash flows determine revenue requirements and
25219 lead to changes in power and transmission rate pressures.

25220 The financial analysis estimates the present value of cash flows over a 30-year timeframe and
25221 considers both upfront capital costs for new resources and structural measures, as well as the
25222 ongoing costs to operate and maintain these facilities. The analysis also includes the gained or
25223 lost revenue due to changes in generation.

25224 Bonneville's official 2019 inflation forecast was used to escalate the annual costs over the 30-
25225 year period. Upfront capital costs were stated in 2022 dollars and all capital was assumed to be
25226 spent in 2022 for purposes of this analysis. All resource additions were assumed to be available
25227 to serve load in 2023. All cash flows were then adjusted to 2019 dollars for consistency with the
25228 cost estimates throughout the CRSO EIS.

25229 **Step 6: Assess Social and Economic Effects of the Changes in Power and Transmission.**

25230 This analysis evaluates social and economic effects in terms of the changes in social welfare,
25231 regional economic effects, and other social effects. The social welfare analysis relies on
25232 modeling outputs and analyses conducted as part of Steps 1 through 4 and the regional
25233 economic effects analysis relies on the modeling and rate analyses of Step 5. The analysis and
25234 tables in this section present all monetary values in 2019 dollars, relying on inflation estimates
25235 from the Bureau of Economic Analysis and Bonneville. Further details on methods and results
25236 are presented in Appendix H. Other social effects are assessed qualitatively.

25237 • **Social Welfare Effects:** From an economic perspective, the conceptual basis for measuring
25238 economic value is society's "willingness to pay" for a good or service.³⁷ Absent data to
25239 directly measure willingness to pay, it is common to develop estimates based on additional
25240 indicators of value, including market prices and replacement costs. This analysis applies two
25241 separate methods to estimate social welfare values of the changes in power generation and
25242 transmission. Both methods are consistent with the Corps' guidance for valuing social welfare

³⁶ A risk-adjusted discount rate is used for making investment decisions. It includes a risk premium, resulting in a higher discount rate that has the effect of reducing the present values of riskier investments for which the expected return on investment is increasingly uncertain over time. The Bonneville risk-adjusted discount rate of 7.9 percent represents the Bonneville average cost of debt at 3.9 percent, then a 4 percent risk premium added to account for cost uncertainty over the term of the analysis.

³⁷ Willingness-to-pay measures the maximum amount that an individual (or population) would be willing to pay rather than do without a good or service above and beyond what the individual (or population) does pay.

25243 effects of changes in power and are presented as changes relative to the No Action
25244 Alternative.³⁸

25245 The “market price method” for estimating social welfare effects describes the
25246 incremental changes in Pacific Northwest hydropower generation (from the HYDSIM
25247 model) under each alternative valued at the market price of power (from the AURORA
25248 model). AURORA estimates market prices based on hourly demand and operating cost
25249 information for each generating plant. The market price method multiplies the average
25250 monthly market prices by the monthly changes in power generation and sums over
25251 months to estimate the average annual value of the change in hydropower generation
25252 under each MO relative to the No Action Alternative. At market equilibrium, the market
25253 prices of a good (i.e., power) exactly equals the marginal value to the buyers and the
25254 marginal cost to sellers. Thus, the market price method is one estimate of the economic
25255 value (i.e., societal willingness to pay) for the lost (or gained) hydropower generation.

25256 However, if the change in output (i.e., power generation) is enough to affect its market
25257 price, or if there are structural changes in demand or supply resulting from the MOs, the
25258 market prices may not provide a valid measure of the economic value of the change (the
25259 market price reflects the marginal cost of power and does not capture the larger cost of
25260 new resources when the incremental change in power is not small). In this scenario, the
25261 change in hydropower generation may affect market prices and is also subject to
25262 structural changes in supply (e.g., replacing hydropower with other sources of
25263 hydropower generation). This analysis therefore applies an alternative method of
25264 estimating social welfare effects based on the costs of providing equivalent power
25265 output under each MO.

25266 This second method, the “production cost method,” quantifies the value of the changes
25267 in power generation based on the costs of providing an equivalent amount of power
25268 (i.e., maintaining reliability for consumers).³⁹ The production cost method estimates
25269 economic effects based on changes in the fixed and variable costs of meeting the
25270 regional demand for power. The fixed costs include the annualized capital costs of
25271 developing new capacity (i.e., replacement resources) and connecting it to the system
25272 (i.e., transmission infrastructure costs). The variable costs included the changes in the
25273 cost of fuel, start-up costs, variable operations and maintenance, and, where relevant,

³⁸ The Corps’ guidance describes the following: “Primary benefit measure for hydropower: Market value of output, or alternative cost of providing equivalent output when market price does not reflect marginal costs.” (Source: U.S. Army Corps of Engineers Institute for Water Resources. June 2009. National Economic Development Procedures Manual.)

³⁹ The U.S. Water Resources Council’s Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies and the associated Corps’ guidance specify that this cost-based method (referred to as the “cost of the most likely alternative”) may be used to estimate willingness to pay if the alternative means of producing the power reflected in the costs is the “most likely” alternative means, and that society would, in fact, undertake the alternative means. In this case, it is reasonable to find that the foregone power would be replaced as the demand for power is relatively inelastic. As there is some uncertainty regarding how reductions in hydropower generation would be replaced, however, the analysis provides a range of social welfare effects based on this method.

25274 emissions penalties in California for the various generating resources across the
25275 Western Interconnection under each MO. The production cost method provides a range
25276 of results based on the alternative replacement resource portfolios (as described in
25277 Step 3).

25278 These two methods are distinct approaches for estimating the social welfare effects of
25279 the MOs. Therefore, the resulting value estimates are not additive. The social welfare
25280 effects provide a national perspective on the economic effects of changes in power and
25281 transmission but do not consider how these changes affect particular populations or
25282 regional economies.

25283 • **Regional Economic Effects:** A separate measure of economic effects, the regional economic
25284 effects analysis considers the potential for county-level changes in the costs of living and
25285 doing business for Pacific Northwest residents and businesses. The analysis additionally
25286 presents potential effects outside the Pacific Northwest across the Western
25287 Interconnection. The analysis relies on Census data and mapping to establish the geographic
25288 area and regional demographics of the potentially affected populations.

25289 The regional economic effects consider changes in how much residents and businesses
25290 would pay for electricity over a 20-year timeframe. This requires estimating the average
25291 county-level retail rate and load based on NW Council forecasts. The forecasts for retail
25292 rates and loads for residential consumers include low, medium, and high portfolios,
25293 which reflect the uncertainty of these forecasts.

25294 The analysis additionally accounts for end-user responses to price changes (i.e., reducing
25295 demand due to a price increase), also referred to as elasticity of demand, which
25296 considers the estimated short- and long-term elasticities for residential and commercial
25297 user groups based on EIA data.

25298 The regional economic analysis additionally considers how potential changes in the cost
25299 of electricity may affect productivity (e.g., employment and output) across
25300 interconnected industries within the regional economy. This may occur, for example, if
25301 the increased cost of electricity changes household spending patterns, reducing the
25302 demand for other goods and services in the region. This analysis applies IMPLAN to
25303 model the increased spending on electricity as a reduction in household income (direct
25304 effect) and quantifies the multiplier effects on interrelated economic sectors (indirect
25305 and induced effects). IMPLAN is a widely used industry-standard input-output data and
25306 software system that is used by many Federal and state agencies to estimate regional
25307 economic effects.⁴⁰ The underlying data for IMPLAN is derived from multiple sources,
25308 including the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the U.S.
25309 Census Bureau.

⁴⁰ For more information on the IMPLAN® system, visit <http://www.implan.com/>.

25310 • **Other Social Effects:** The qualitative assessment of other social effects considers how
25311 people may be affected by the changes in power and in transmission outside of the
25312 estimated social welfare and regional economic effects. This assessment focuses in
25313 particular on the potential health and safety effects under each alternative.

25314 A key factor influencing this analysis is the extent of coal plant retirements and their availability
25315 to serve regional demand for power primarily by the region’s IOUs (relevant to the No Action
25316 Alternative and the MOs). The section below highlights this issue and describes how the
25317 analysis of each alternative will also explain the sensitivity of the results that rely on base case
25318 coal-retirement assumptions formed in 2017 to new information regarding the future
25319 availability of coal resources.

25320 **ADDITIONAL POWER RATE SENSITIVITY ANALYSIS AND OTHER REGIONAL COST PRESSURE**
25321 **ANALYSIS**

25322 **Overview of Rate Sensitivity Analysis and Regional Cost Pressure Analysis**

25323 The base case power rate analysis described in Step 5 above relies on a number of assumptions
25324 regarding resource availability, resource costs, coal-plant retirements, carbon policies, and
25325 other factors that affect the resulting power rate pressure effects. Some of these assumptions
25326 have changed or have been updated since the power rate analysis for the base case was
25327 developed. Where practicable, the base case analysis has been updated to reflect the most
25328 recent information. For other areas, revising the entire rate analysis with the updated or new
25329 information was not practicable given timing and analytical constraints. To capture the effect of
25330 this new or updated information, additional rate sensitivity analysis is included along with the
25331 base case “Bonneville Finances” rate table described in Step 5 above. The specific rate
25332 sensitivities addressed include the following:

- 25333 • Fish and Wildlife Costs
- 25334 • Integration Services (Hydro Flexibility)
- 25335 • Resource Financing Assumptions
- 25336 • Resource Cost Uncertainties (Contingencies)
- 25337 • Demand Response
- 25338 • Oversupply

25339 A more detailed description of each sensitivity is provided below in the section heading titled
25340 “Rate Sensitivity Analysis Assumptions.”

25341 In addition to the base case analysis and the six rate sensitivities discussed above, analysis was
25342 performed to assess the impacts of other regional cost pressures, including the potential
25343 incremental costs to the region associated with (1) carbon compliance, and (2) accelerated
25344 retirement (capital costs and other costs). As discussed more fully below under the heading of
25345 “Assumptions Used in Other Regional Cost Pressure Analysis,” regional carbon policy changes

25346 and updated coal retirement schedules will likely change the resource mix and availability
25347 assumed in the base case analysis. Additionally, as carbon policies and coal retirements remain
25348 fluid, estimating the potential costs associated with these anticipated changes was too
25349 speculative to be included in the rate sensitivity analysis. Nonetheless, as these variables
25350 become more defined, they will likely present additional costs to the region. The other regional
25351 cost pressure analysis was developed to provide a general assessment for each MO of the
25352 potential incremental costs to regional utilities from carbon compliance and accelerated coal
25353 retirement. To be clear, the analysis does not present the cost to Bonneville's wholesale power
25354 rate alone, and the impact of these variables on Bonneville's rate is uncertain. Instead, this
25355 analysis presents a regional view of the potential incremental costs (if known) for the
25356 alternative in light of recent carbon policy changes and expected coal retirements.

25357 **Description of Base Case, Rate Sensitivity Analysis, and Other Regional Cost Pressure Analysis**
25358 **Tables**

25359 The results of the base case, rate sensitivity, and other regional cost pressure analyses are
25360 presented in each MO under the section heading *Wholesale Power Rates* in two connected
25361 tables. The first table, the "Change in Bonneville's Priority Firm Tier 1 Rate, Bonneville Finances"
25362 table provides the output of the base case analysis (from Step 5) and the rate sensitivity
25363 analysis. This table also combines and summarizes the range of potential rate impacts of the
25364 MO on Bonneville's wholesale power rate.

25365 The second table, the "Other Regional Cost Pressure Analysis," table, reflects the incremental
25366 cost to the region of the MO in light of potential carbon compliance and accelerated coal
25367 retirements. As noted above, this table provides potential regional costs or savings and does
25368 not specify what portion of these costs or savings would apply to Bonneville or be recovered in
25369 Bonneville's wholesale power rates.

25370 Below is an example of the tables that are included in each MO and the Preferred Alternative
25371 with each element of the analysis labeled (Figure 3-174).

	Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
	\$ rate pressure	change from NAA	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)				
Base Rate	Base Case Analysis		\$ /MWh	\$ /MWh
Change from NAA due to Costs	\$	%	\$	%
Change from NAA due to Load		%		%
Total Base Change in Rate		%		%
Rate Sensitivities (annual cost in \$ millions)				
Fish and Wildlife Costs	\$ to \$	% to %	\$ to \$	% to %
Integration Services	\$ to \$	% to %	\$ to \$	% to %
Resource Financing Assumptions	\$ to \$	% to %	\$ to \$	% to %
Resource Cost Uncertainties	\$ to \$	% to %	\$ to \$	% to %
Demand Response	\$ to \$	% to %	\$ to \$	% to %
Oversupply	\$ to \$	% to %	\$ to \$	% to %
Total Rate Sensitivities	\$ to \$	% to %	\$ to \$	% to %
Base Case + Rate Sensitivity Analysis				
Total Base Effect + Sensitivities	\$ to \$	% to %	\$ to \$	% to %
Other Regional Cost Pressure (annual cost in \$ millions)				
	Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
	\$ pressure	change from NAA	\$ pressure	change from NAA
Regional Cost of Carbon Compliance	\$ to \$		\$ to \$	
Regional Coal Retirements (capital)	\$ to \$		\$ to \$	
Regional Coal Retirements (other)	\$ to \$		\$ to \$	

Figure 3-174. Change in Bonneville’s Priority Firm Tier 1 Rate, Bonneville Finances

25372
25373

25374 **Rate Sensitivity Analysis Assumptions**

25375 As described above, the rate sensitivity analysis considers the impact on power rates of six
25376 additional cost variables not captured within the base case analysis. Below is a brief description
25377 of each variable considered in the rate sensitivity analysis.

25378 **Fish and Wildlife Costs**

25379 In 2016, Bonneville’s Fish and Wildlife Program budget was \$267,000,000, and the Lower Snake
25380 River Compensation Plan (LSRCP) budget was \$32,303,000 (\$281,536,000 and \$34,062,000,
25381 respectively, when adjusted to 2019 dollars). The Bonneville Fish and Wildlife Program Budget
25382 for the No Action Alternative, \$281,536,000, was included in the Base Case analysis for each of
25383 the alternatives. The Base Case analysis also included \$34,062,000 for the costs of the LSRCP for
25384 the No Action Alternative, MO1, MO2, and MO4. Upon the breaching of the lower Snake River
25385 dams under MO3, Bonneville would no longer have an obligation to fund the operations and
25386 maintenance of the LSRCP because Bonneville’s funding authority is directly tied to the
25387 operation of the lower Snake River projects.

25388 For several of the alternatives, Bonneville analyzed a range of potential Fish and Wildlife
25389 Program costs to acknowledge the possibility that some of the alternatives could impact the
25390 biological benefits for fish and wildlife and that this could, in turn, change the need for some
25391 offsite mitigation⁴¹. By analyzing a range of costs, Bonneville reflects the year-to-year
25392 fluctuations related to managing its Fish and Wildlife program and also acknowledges the
25393 uncertainty around the magnitude of biological effects under the various alternatives and the
25394 potential impacts on funding, including the timing of funding decisions. For this reason,
25395 potential adjustments to the Bonneville Fish and Wildlife Program under MO2, MO3, and MO4
25396 are analyzed separately as part of the Rate Sensitivity analysis.

25397 As previously discussed, funding decisions for the Bonneville Fish and Wildlife Program are not
25398 being made through the CRSO EIS process. Future budget adjustments would be made in
25399 consultation with the region through Bonneville's budget-making processes and other
25400 appropriate forums and consistent with existing agreements.

25401 ***Integration Services***

25402 As discussed in Section 3.7.2.2, the CRS provides the region flexibility and ramping capability
25403 that is important for power and transmission system reliability, meeting load variability,
25404 integrating intermittent resources (such as wind and solar), and providing operational reserves
25405 for both unexpected generation outages in the region as well as unexpected load deviations.
25406 Because LOLP studies can understate the value of this flexibility, analysis was performed to
25407 consider this additional value.

25408 The current CRSO EIS estimates for the cost of renewable replacement resources do not include
25409 costs for integration services (operating or generation balancing reserves) for the additional
25410 variable generation resources. The quantity of generation balancing reserves needed to
25411 integrate the renewable replacement resources for each of the MOs was informed by
25412 Bonneville's methodologies for forecasting generation balancing reserve requirements. This
25413 approach showed that a resource with 100 MW nameplate capacity would require 20-25 MW
25414 of reserves and that as the aggregate regional installed solar capacity increases, so does the
25415 reserve requirement (measured as a percentage of installed capacity). The sensitivity analysis
25416 included here assumes the upper end of this range (25 percent). It is important to note that the
25417 FCRPS may only be able to provide roughly 300 MW of additional reserves before non-federal
25418 capacity would have to be purchased to meet any additional reserves requirement. Thus, costs
25419 could be higher than the current costs estimates for reserves provided by the FCRPS.⁴²

25420 To estimate the cost of these generation balancing reserves, Bonneville used the embedded
25421 cost of holding capacity from Bonneville's most recent rate case (BP-20 rate case) multiplied by
25422 the expected reserve needed. This gives a single-point estimate, in order to provide a range of

⁴¹ Off-site mitigation actions typically address impacts to fish and wildlife not caused directly by the CRS projects, but they are actions that can improve the overall conditions for fish to help address uncertainty related to any residual adverse effects of CRS project management.

⁴² For example, an LMS100 was used to establish the BP-20 demand rate of \$10.29/kW-mo, and resource price increase trajectories in the 7th Power Plan indicate those costs could increase to almost \$16/kW-mo by FY 2032.

25423 costs, the upper bound adds the variable costs for regulation and following reserves (at the BP-
25424 20 average rate), while the lower bound estimate excludes the variable components of the
25425 reserves.⁴³

25426 Operating reserve costs also use the BP-20 rates of \$9.53/MWh for spinning⁴⁴ reserves and
25427 \$8.32/MWh for supplemental⁴⁵ reserves. (Reliability standards require generation to carry 3
25428 percent of expected generation into the next scheduling hour, half consisting of spinning
25429 reserves and half as supplemental reserves.)

25430 The expected costs of balancing and operating reserves for the replacement resource portfolios
25431 are shown in Table 3-113, Table 3-114, and Table 3-115.

25432 **Table 3-113. Balancing and Operating Reserves Costs for Replacement Resources (Low Range)**

Alternative	Low Range Average Dispatch (MWh)	Spinning Charge (1.5% of Dispatch, \$9.53/MWh, in \$million)	Supplemental Charge (1.5% of Dispatch, \$8.32/MWh, in \$million)	Total Charge (\$million)
Low Range				
<i>MO1</i>				
Conventional Least-Cost	239,000	\$0.0	\$0.0	\$0.1
Zero Carbon	2,838,000	\$0.4	\$0.4	\$0.8
<i>MO3</i>				
Conventional Least-Cost	6,017,000	\$0.9	\$0.8	\$1.6
Zero Carbon	6,019,000	\$0.9	\$0.8	\$1.6
<i>MO4</i>				
Conventional Least-Cost	1,426,000	\$0.2	\$0.2	\$0.4
Zero Carbon	11,772,000	\$1.7	\$1.5	\$3.2

25433 **Table 3-114. Balancing and Operating Reserves Costs for Replacement Resources (High Range)**

Alternative	High Range 1937 Dispatch (MWh)	Spinning Charge (1.5% of Dispatch, \$9.53/MWh, in \$million)	Supplemental Charge (1.5% of Dispatch, \$8.32/MWh, in \$million)	Total Charge (\$million)
High Range				
<i>MO1</i>				
Conventional Least-Cost	525,000	\$0.1	\$0.1	\$0.1
Zero Carbon	2,838,000	\$0.4	\$0.4	\$0.8

⁴³ To define the variable component Bonneville estimated efficiency losses. When Bonneville holds reserve capacity, it incurs additional costs due to efficiency losses. Efficiency losses are impacts to the Federal system and are a function of the generation output in megawatts, timing of energy generated, and revenues received. These costs are calculated by the GARD model and added to the embedded unit cost of capacity to get a total cost of capacity.

⁴⁴ Spinning reserve is the extra generating capacity that is available by increasing the power output of generators that are already connected to the power system 'spinning' and can respond in seconds.

⁴⁵ Supplemental reserve or non-spinning reserve is the extra generating capacity that is not currently connected to the system but can be brought online after a short delay (minutes)

Alternative	High Range 1937 Dispatch (MWh)	Spinning Charge (1.5% of Dispatch, \$9.53/MWh, in \$million)	Supplemental Charge (1.5% of Dispatch, \$8.32/MWh, in \$million)	Total Charge (\$million)
High Range				
<i>MO3</i>				
Conventional Least-Cost	7,047,000	\$1.0	\$0.9	\$1.9
Zero Carbon	6,019,000	\$0.9	\$0.8	\$1.6
<i>MO4</i>				
Conventional Least-Cost	2,854,000	\$0.4	\$0.4	\$0.8
Zero Carbon	11,772,000	\$1.7	\$1.5	\$3.2

25434 **Table 3-115. Generation Balancing Reserve Costs for Zero-Carbon Replacement Resources**

Alternative	Capacity	Assumed Capacity Factor	Low Range Balancing Cost @ \$7.85/kW-mo (\$million)	High Range Balancing Cost @ \$9.23/kW-mo (\$million)
MO1 - Zero Carbon	1,200	0.25	\$28.3	\$33.2
MO3 - Zero Carbon	2,550	0.25	\$60.1	\$70.6
MO4 - Zero Carbon	5,000	0.25	\$117.8	\$138.5

25435 **Resource Financing Assumptions**

25436 Resource financing assumptions are a substantial part of calculating the cost of building a
 25437 resource. The base case analysis includes the cost of building new resources, with assumptions
 25438 about both interest rate and term. Of these two variables, the base case analysis considers
 25439 differences in the interest rate costs when either Bonneville or other regional entities replace
 25440 the resources. The base case analysis, however, does not consider different potential outcomes
 25441 when the term of the debt repayment is shorter than 30 years, a length of time that likely
 25442 represents the maximum amount of time that any entity would finance a new generating
 25443 resource. Importantly, the term of the debt repayment can have a significant impact on retail
 25444 rates. Hence, it is important to consider how different debt terms can impact this analysis.

25445 While 30 years is about the maximum that most entities would finance a generating resource,
 25446 the NW Council includes terms as short as 15 years and maximum terms of 25 years for wind
 25447 and solar resources in its resource pricing model, MicroFin. Fifteen years is most likely
 25448 appropriate for independent power producers without a rate base to recover the cost when
 25449 resources run shorter than their expected operating lives. Even from Bonneville’s perspective,
 25450 however, a shorter debt issuance is a potential outcome. For example, certain of the MOs use
 25451 solar replacement resources that, according to the NW Council are generally financed between
 25452 20 and 25 years. Further, by law Bonneville cannot own resources and will need to buy the
 25453 output from resource owners with potentially shorter time horizons that would ultimately pass
 25454 on those shorter cost-recovery time horizons to Bonneville. Thus, when considering resource
 25455 financing assumptions, it is important to consider the cost to ratepayers of shorter financing
 25456 horizons which would increase the first-year cost to rate payers by 0.3 to 5.6 percent from the

25457 base case analysis. Table 3-116 and Table 3-117 summarize the generating resources debt term
25458 findings.

25459 **Table 3-116. Generating Resource Debt Terms by Developer Type (in years)**

Resource	Natural Gas	Wind	Geothermal	Solar
Municipal/PUD	30	25	25	25
Investor-Owned Utility	30	25	30	25
Independent Power Producer	15	20	20	20

25460 **Table 3-117. Increase in Annual Costs for Shorter-Term Financing (20-year cost recovery,**
25461 **\$ million and in %)(in millions)**

Alternative	Bonneville Finances	
	Zero Carbon	Conventional Least Cost
MO1	30.1	5.7
MO2	N/A	N/A
MO3	86.6	23.7
MO4	125.5	32.8
(in %)	Bonneville Finances	
	Zero Carbon	Conventional Least Cost
MO1	1.4%	0.3%
MO2	N/A	N/A
MO3	4.1%	1.1%
MO4	5.6%	1.6%

25462 **Resource Cost Uncertainties**

25463 The overnight capital costs for the replacement resources in this analysis were the mid-point
25464 from the NW Council’s 7th Power Plan Mid Term Update.^{46,47} In this mid-term update, the NW
25465 Council updated the capital costs of solar and single and combined cycle gas turbines. Because
25466 only the single mid-point was used in the CRSO EIS analysis there are resource cost
25467 uncertainties that could result in higher and lower cost outcomes for the MOs.⁴⁸ In Table 3-118,
25468 the zero-carbon portfolios for MO1, M03, and M04 reflect the resource need for solar in
25469 megawatts and the ranges of potential capital costs in dollars per kW, using the resource cost
25470 uncertainties estimates.

⁴⁶ Published on February 26, 2019. <https://www.nwcouncil.org/reports/midterm-assessment-seventh-power-plan>
⁴⁷ Overnight capital cost (\$/kW) is an estimate of the project development and construction cost, where ‘overnight’ refers to what the cost would be if the plant were built instantly, or over one night. This includes engineering, procurement, and construction, as well as other costs incurred by the project developer.
⁴⁸ The Council’s 7th Power Plan Mid-Term updated the overnight cost of capital in real 2016 dollars. The numbers represented in this table are updated to real 2022 dollars.

25471 **Table 3-118. Solar Resource Need (MW) for the Zero-Carbon Portfolio and Potential**
25472 **Overnight Capital Costs (\$/kW)**

Alternative	Need (MW)	Solar Capital Costs (2022\$/kW) ^{1/}			Total Investment Low (\$2022 billions)	Total Investment Mid-Point (\$2022 billions)	Total Investment High (\$2022 billions)	Range (\$2022 billions)
		Low	Mid-Point	High				
MO1	1,200	\$1,507	\$1,591	\$1,675	\$1.81	\$1.91	\$2.01	\$0.20
MO3	2,550	\$1,507	\$1,591	\$1,675	\$3.84	\$4.06	\$4.27	\$0.43
MO4	5,000	\$1,507	\$1,591	\$1,675	\$7.54	\$7.95	\$8.37	\$0.84

25473 Note: 1/ Midterm Assessment of the 7th Power Plan page 6-4 (Solar Photovoltaic)

25474 In Table 3-119, the conventional least-cost portfolios reflect the need for replacement
25475 resources for natural gas fired power plants. The differences in capital costs of M03 compared
25476 to M01 and M04 reflect that a combined cycle power plant was more cost-effective for M03
25477 than the single cycle plants selected for M01 and M04. It is not cheaper in terms of capital
25478 costs, but rather more cost-effective in terms of being a more efficient unit that has a better
25479 heat rate (uses less fuel per unit of electrical energy created).

25480 **Table 3-119. Natural Gas Resource Need (MW) for the Conventional Least-Cost Portfolio and**
25481 **Potential Capital Costs**

Alternative	Need (MW)	Gas Capital Costs (2022\$/kW) ^{1/}			Total Investment Low (\$2022 billions)	Total Investment Mid-Point (\$2022 billions)	Total Investment High (\$2022 billions)	Range (\$2022 billions)
		Low	Mid-Point	High				
MO1	560	\$558	\$642	\$726	\$0.31	\$0.36	\$0.41	\$0.09
MO3	1120	\$1,228	\$1,340	\$1,451	\$1.38	\$1.50	\$1.63	\$0.25
MO4	3240	\$558	\$642	\$726	\$1.81	\$2.08	\$2.35	\$0.54

25482 Note: 1/ Midterm Assessment of the 7th Power Plan page 6-4 (MO1 and M03 Frame GT; M03 CCCT Adv West
25483 Cooling)

25484 ***Demand Response Analysis for CRSO***

25485 Many utilities have proven success in leveraging demand response as a tool for summer/winter
25486 peaking and load-shifting, for deferment of transmission or distribution investments, or for
25487 economic purposes in times of high market prices. It is generally recognized that there are two
25488 types of demand response (DR): (1) firm DR capacity, and (2) non-firm DR capacity. Firm DR
25489 capacity generally includes all types of Direct Load Control, Third Party DR contracts (where the
25490 service provider has an obligation for performance) and Irrigation. Firm DR has hour and
25491 frequency-of-use limitations, depending on the load type. Non-firm DR capacity includes pricing
25492 strategies and behavioral demand response in which the utility is dependent on consumer
25493 action to achieve a capacity goal. Bonneville only considers firm DR capacity in evaluating
25494 substitutes for firm generation.

25495 **Assumptions Used in Base Case Analysis:** The CRSO base case analysis uses the NW Council's
25496 7th plan for costs and amounts of achievable demand response. Consistent with the 7th Power
25497 Plan's estimates, the analysis assumes 400 MW of demand response developed in the near-
25498 term by Bonneville, in partnership with Bonneville's power customer utilities, and another 200
25499 MW of demand response developed by regional investor owned utilities.

25500 The lowest cost demand response product identified for the 7th Power Plan had a twenty-year
25501 levelized cost of \$45/kW-Year (2012\$), which is the value assumed in the base case rates
25502 analysis. The NW Council's levelized costs include all costs⁴⁹ required to continually implement
25503 the demand response over the twenty-year NW Council planning period. The 7th Power Plan
25504 identified additional technically and economically achievable regional demand response
25505 available at higher costs up to \$55/kW-year.

25506 **Rate Sensitivity for Demand Response:** Demand response is an innovative and economical
25507 means for displacing peaking resources by shifting load and thus meeting future planning
25508 needs. New technologies are continually improving demand response, reducing its costs and
25509 increasing its effectiveness. At the same time, demand response at levels assumed in the base
25510 case analysis remains largely untested. In the Pacific Northwest, demand response has occurred
25511 primarily through pilot programs at levels below the scale assumed in the base case analysis.
25512 As such, there is uncertainty around the ability of demand response to manage load variation,
25513 resource integration, and operation and generation balancing reserve needs at the levels
25514 needed to replace lost generating capability for some of the MOs. To quantify these
25515 uncertainties, a demand response sensitivity was included in the rates analysis to address two
25516 variables: (1) cost of demand response; and (2) availability of demand response.

25517 The cost variable updates the demand response cost assumptions used in the base case analysis
25518 (data from the 7th Power Plan⁵⁰) with more recent study information. Specifically, the Cadmus
25519 Group performed a study that found that demand response, consisting of both for Firm and
25520 non-firm demand response actions, could be achieved for as low as \$17.31/kW-year (2017\$) in
25521 the region in the near term. (Cadmus Final Report, 9/20/19, pages xi and 30).⁵¹ If the Cadmus
25522 cost assumption is used, the cost of demand response is reduced compared to the base case
25523 analysis. The Cadmus Group's analysis is presented as a "low end" sensitivity, and not a
25524 replacement for the cost data from the 7th Power plan, because the Cadmus Group cost
25525 estimate includes both Firm and non-Firm forms of demand response (whereas the 7th Power
25526 Plan differentiated between Firm and non-Firm).

25527 The second variable considered in the demand response sensitivity was availability. The base
25528 case assumes that Bonneville and the region would achieve 600 MW of firm demand response,
25529 thereby obviating the need to construct additional resources. If accomplished, this would be an

⁴⁹ Costs included Bonneville/utility staffing costs, marketing and load recruitment costs, capacity reservation incentives, event participation incentives, technology enablement cost, and equipment installation costs

⁵⁰ NW Council's 7th Power Plan, Chapter 3, page 3-22

⁵¹ This report is available at <https://www.bpa.gov/EE/Technology/demand-response/Pages/dr-potential-and-barriers-studies.aspx>.

25530 unprecedented regional achievement. At the same time, there is uncertainty as to the
25531 effectiveness and achievability of demand response in the size assumed in the base case
25532 analysis. To reflect this uncertainty, the demand response sensitivity includes an “upper end”
25533 cost sensitivity to reflect the potential change in resource replacement costs if some of the firm
25534 demand response included in the base analysis were unavailable and alternate, more
25535 expensive, resources were needed. The upper end of the demand response sensitivity analysis
25536 assumes as much as half of demand response (300 MW) would be replaced by a combination of
25537 solar resources and battery technology.

25538 **Oversupply**

25539 Bonneville uses the Oversupply Management Protocol (OMP) to moderate TDG levels in the
25540 Columbia River to protect endangered fish and other aquatic species. The requirements and
25541 procedures for OMP are contained in Attachment P to Bonneville’s Tariff. Oversupply typically
25542 occurs in the spring when there are high flows. High flows require spilling water, which
25543 increases TDG levels, or passing water through generating turbines, resulting in increased hydro
25544 generation. Due to low demand in the spring, it is often challenging for Bonneville to find
25545 additional load for any increased hydro generation. Without additional load, Bonneville must
25546 spill water. In order to moderate TDG levels that occur from additional spill, Bonneville
25547 increases hydro generation by implementing OMP to displace non-Federal generation in its BAA
25548 using a least-cost displacement cost curve. Bonneville takes a number of actions to reduce or
25549 avoid the need for displacement, including selling power down to zero cost.

25550 OMP costs can vary substantially from year to year with different hydrological conditions and
25551 associated hydro generation, in addition to the amount of non-Federal generation running in
25552 the BAA. Generally, in low water years, oversupply events are relatively unlikely, while in high
25553 water years – particularly those with high spring runoff flows – oversupply events are more
25554 likely. Thus, Bonneville generally does not forecast the expected costs of OMP. Bonneville
25555 charges a separate rate to recover any actual costs associated with implementing OMP.

25556 In the CRSO analysis, no provision for recovery of OMP costs is included in base power rates.
25557 However, OMP does present a potential source of rate pressure which could differ materially
25558 based upon water conditions, the supply constraints on the FCRPS associated with each
25559 alternative, and the potential of locating replacement resources in Bonneville’s BAA. To price
25560 oversupply events under each of the MOs, Bonneville used the average historical price paid to
25561 generators displaced for FY2012–FY2019. This price, 29.22\$ per MWh, is based upon actual
25562 costs incurred, and is a reasonable predictor of costs which might be anticipated in the future.
25563 This average price is applied to the expected magnitude of oversupply needs based upon the
25564 3200 modeled iterations for each alternative and replacement scenario. Since AURORA is able
25565 to determine the incidence of oversupply events based upon whether modeled clearing prices
25566 are less than zero, expected magnitudes can be reasonably forecast. To establish the range of
25567 expected costs, the 10th and 90th percentiles are used.

25568 **Assumptions Used in Other Regional Cost Pressure Analysis**

25569 The other regional cost pressure analysis evaluates incremental costs that, while speculative
25570 now, are likely to have broad implications on power costs for the region in the future. Provided
25571 below are descriptions of the cost of carbon compliance and availability of coal resources,
25572 which are the two cost pressures included in the “Other Regional Cost Pressure Analysis” table.

25573 **Cost of Carbon Compliance**

25574 Several states in the western U.S. have passed, or are likely to pass, legislation directed at
25575 decarbonizing the electric grid. California began implementing an economy-wide cap-and-trade
25576 program in 2013. In 2018, the California legislature passed a law seeking to achieve 100 percent
25577 carbon-free electricity by 2045 (Senate Bill 100). Washington enacted the Clean Energy
25578 Transformation Act (CETA) in 2019, requiring that Washington utilities eliminate coal costs from
25579 their retail rates by 2025. CETA also directs Washington retail utilities to serve loads with 100
25580 percent carbon-neutral power by 2030, and 100 percent carbon-free power by 2045 (RCW
25581 19.405). Oregon has been considering a cap-and-trade program similar to California’s program.
25582 Additionally, Nevada (Senate Bill 358, 2019) and New Mexico (Senate Bill 489, 2019) both
25583 adopted 100 percent carbon-free goals for the electricity sector. The province of British
25584 Columbia has had a carbon tax in place since 2008.

25585 The legislative trends suggest that in the future there may be a cost associated with most or all
25586 fossil-fuel-generation located in or serving load in the Pacific Northwest. At a minimum, starting
25587 in 2030, there will be a cost to fossil fuel generation used by utilities to serve retail load in
25588 Washington, which accounts for over 50 percent of total regional load (EIA 2017).

25589 The MOs in the CRSO EIS would affect the amount of hydropower production in the region,
25590 which does not in itself generate greenhouse gas (GHG) emissions. Hydropower production
25591 levels, however, will affect the fuel mix and overall GHG emission levels from the regional
25592 electricity sector. This is because existing resources (other than coal-plants slated for
25593 retirement) continue to operate and may decrease or increase generation in response to
25594 changes in hydropower generation from the CRS projects and non-Federal hydropower projects
25595 in the Columbia River basin. Changes to GHG emission levels would impact states’ abilities to
25596 meet GHG emissions reduction targets. Such changes would also affect compliance costs for
25597 utilities, and ultimately ratepayers, under policies that mandate a price on GHG emissions. This
25598 analysis considers how the MOs could affect regional utilities’ cost of compliance with the GHG
25599 emissions reduction policies mentioned above. The analysis is forward-looking to the early
25600 2030s when Washington’s CETA will be in effect as well as giving time for implementation and
25601 maturation of potential additional GHG emission reduction policies.

25602 The analysis presents a low and high estimate of how the MOs could affect the regional cost of
25603 compliance with GHG emission reduction policies. The low assumption uses the auction reserve
25604 price (the floor) for California’s cap-and-trade program to represent a conservative price on
25605 carbon in the early 2030s. The 2019 auction reserve price is \$15.62 per allowance and rises
25606 annually by 5 percent plus the rate of inflation. An allowance is the compliance instrument that

25607 entities acquire for one metric ton of CO₂ equivalent (MT CO₂e). This analysis estimates that in
 25608 2030 the auction reserve price will be \$33.77, meaning that this would be the cost equated to
 25609 one MT CO₂e. The high assumption uses the administrative fee under Washington’s CETA to
 25610 represent a reasonably high price on carbon in the early 2030s. Under CETA, the administrative
 25611 fee applies to each MWh of emitting generation. The fee is \$150 per MWh for coal-fired
 25612 resources, \$84 per MWh for gas-fired peaking plants, and \$60 per MWh for gas-fired combined-
 25613 cycle plants. Starting in 2027, these fees rise annually at the rate of inflation. This analysis
 25614 estimates that in 2030 the CETA administrative fee will be \$162.54 per MWh for coal-fired
 25615 resources, \$91.02 per MWh for gas-fired peaking plans, and \$91.02 per MWh for gas-fired
 25616 combined-cycle plants. For comparison, this is similar to the price ceiling for California’s cap-
 25617 and-trade program, which this analysis estimates will be around \$121.84 in 2030, which could
 25618 be a closer indicator than the reserve (floor) price of future allowance prices in California and
 25619 similar cap-and-trade programs as the supply of allowances tightens in the future.

25620 Consistent with the air quality and power analysis in Sections 3.7 and 3.8, emissions and
 25621 resource amounts are based on the 2022 AURORA power markets model outputs. Potential
 25622 future coal plant retirements present a source of uncertainty and to the extent coal generation
 25623 is replaced by natural gas and renewables the estimates in Table 3-120 may overestimate the
 25624 cost of compliance. However, this analysis also errs conservatively on the price of carbon by
 25625 using prices in the year 2030 even though prices will continue to annually escalate beyond then.

25626 **Table 3-120. Annual Change in Cost of Compliance with GHG Emissions Reduction Policies for**
 25627 **MOs, Pacific Northwest, 2030 (\$ in Millions)**

Total Cost Annual	Resource Replacement	MO1	MO2	MO3	MO4
Low Estimate (millions)	Conv. Least-Cost Replacement	\$11.3	-\$37.3	\$109	\$104
	Zero-Carbon Replacement	-\$16.4		\$33.9	\$10.3
High Estimate (millions)	Conv. Least-Cost Replacement	\$57	-\$193.7	\$622.5	\$561
	Zero-Carbon Replacement	-\$88.4		\$168.1	\$36.8

25628 This analysis does not consider the impacts that the MOs would have on Bonneville’s fuel mix
 25629 should Bonneville acquire the replacement resources. To the degree that replacement
 25630 resources may cause Bonneville’s fuel mix to include more carbon that would impart a
 25631 regulatory cost onto utilities that purchase from Bonneville and are subject to state carbon-
 25632 pricing programs such as CETA. This analysis also does not consider how changes in Bonneville’s
 25633 fuel mix (and accompanying changes in the carbon content attributed to Bonneville’s power
 25634 sales) could impact the value of Bonneville’s surplus sales to states outside of the Pacific
 25635 Northwest with GHG emissions reduction programs, such as the value of surplus sales to
 25636 California. Lastly, this analysis is distinctly different than the social cost of carbon analysis in
 25637 Section 3.7. The values in Table 3-120 above represent a regulatory cost that is directly borne
 25638 by regional utilities and ratepayers resulting from changes in the regional electricity sector’s
 25639 fuel mix and GHG emissions. In contrast, the social cost of carbon calculates the economic harm
 25640 resulting from the impacts to society that GHG emissions impose on a global scale.

25641 **Availability of Coal Resources**

25642 Energy economics and state and local de-carbonization policies are changing the generation
25643 portfolio in the region and across the Western Interconnection into the 2020s and
25644 beyond. Therefore, the base case analysis for the power and transmission analysis in the CRSO
25645 EIS, established at the outset for modeling in 2017, no longer reflects the current understanding
25646 of resources that will be available to serve load in the future. Additional and accelerated coal
25647 retirements have been announced and more are being contemplated, mainly impacting the
25648 region’s IOUs, which use these resources to serve their retail loads.

25649 The urgency of regional resource adequacy was made clear in a March 2019 report written by
25650 E3 (2019) on behalf of Puget Sound Energy, Avista, Northwestern Energy, and the Public
25651 Generating Pool. According to E3, the retirement of coal power supplied to the Northwest
25652 states threatens to create an electric power supply shortage of up to 8 GW by 2030. Regional
25653 utilities, including Bonneville, have begun working together to address the issue.

25654 CETA mandates the elimination of electricity produced by coal used by all utilities in
25655 Washington by 2025 (Washington SB5116, 66th Legislative Session, 2019 Regular Session).
25656 The Oregon Clean Energy and Coal Transition Act (2016) mandates the elimination of the cost
25657 of coal resources in retail rates of IOUs by 2030 (Oregon SB1547, 78th Legislative Assembly,
25658 2016 Regular Session).

25659 The No Action Alternative assumes 1,675 MW of retired coal capacity and a continued coal
25660 capacity of 4,246 MW. This is the assumption underlying the base analysis and the results
25661 presented in this section, except where otherwise noted. To understand the implications that
25662 additional coal retirements would have on available replacement resources and resource
25663 adequacy in the region, this EIS considers two scenarios that address additional coal plant
25664 retirements: The first scenario is “**limited coal retirement.**” This analysis represents retiring an
25665 additional 2,505 MW of coal generation compared to the No Action baseline (Table 3-121;
25666 Section 3.7.3.2, Table 3-132). This assumption represents coal plants that have been announced
25667 to retire in the 2020s. Under this scenario, only Colstrip unit 4 and Jim Bridger units 3 and 4
25668 remain. The second scenario assumes the retirement of all coal plants operating in the
25669 Northwest or serving Northwest loads (“**no coal**”)(Section 3.7.3.2, Table 3-132).

25670 **Table 3-121. Assumed Megawatts of Coal Plant Capacity**

No Action Alternative – Base Case		Limited Coal Retirement Portfolio	
Plant	MW ^{1/}	Plant	MW
Centralia 2 (WA)	670	Colstrip 4 (MT)	681
Colstrip 3 (MT)	518	Jim Bridger 3 (WY)	530
Colstrip 4 (MT)	681	Jim Bridger 4 (WY)	530
Hardin (MT)	119		
Jim Bridger 1 (WY)	530		
Jim Bridger 2 (WY)	530		
Jim Bridger 3 (WY)	530		

No Action Alternative – Base Case		Limited Coal Retirement Portfolio	
Plant	MW ^{1/}	Plant	MW
Jim Bridger 4 (WY)	530		
Montana 1 (MT)	4		
North Valmy 2 (NV)	134		
Total	4,246	Total	1,741

25671 Note: The generation values represent the expected annual generation of the plants allocated to serving
 25672 Northwest loads. Thus, the listed generation values are not the full nameplate capacity of each plant.
 25673 1/ Generation values are from the NW Council’s generation resources database for regional studies.

25674 These two scenarios provide an updated understanding of the differences between the CRSO
 25675 alternatives and costs of zero-carbon replacement scenarios by modeling LOLP in light of the
 25676 additional coal plant retirements. However, it is important to recognize that this EIS focuses
 25677 only on coal retirements; it does not attempt to analyze the impact of removing natural gas
 25678 plants in Washington or other states in the 2020s and beyond as may result from 100 percent
 25679 carbon-free electricity standards like the CETA. Accordingly, the analysis on phasing out coal-
 25680 fired generation assumes that no *new* gas-fired generators would be constructed in the region.

25681 **Qualitative Considerations of Alternatives on Competitiveness of Bonneville’s Firm Power**
 25682 **Rates**

25683 The rates analyses discussed for the MOs below provide a snapshot of the power rate pressures
 25684 resulting from the MOs. These analyses, however, do not evaluate the potential long-term
 25685 impacts of the MOs on the competitiveness of Bonneville’s power rates. This additional
 25686 consideration is described here as a general qualitative impact of the MOs but is not quantified
 25687 in the rates analyses.

25688 The MOs’ long-term cost impacts on Bonneville’s wholesale power rates is an important
 25689 qualitative consideration because of the competitive nature of the industry Bonneville operates
 25690 in. Bonneville is statutorily obligated to offer power (which includes the CRS projects) if
 25691 requested to meet its preference customers’ power requirements. However, these utilities are
 25692 not required to purchase Federal power from Bonneville and therefore will have a choice in
 25693 selecting a new power supplier upon the expiration of their current power sales contract in
 25694 2028. Retaining Bonneville’s preference customer base will be critical to assuring Bonneville is
 25695 able to meet its public purposes and financial obligations for the long term. Federal power sales
 25696 to preference customers are an essential source of revenue for Bonneville, making up
 25697 approximately 80 percent of Bonneville’s power revenue. The rates these customers pay
 25698 recover the vast majority of the costs of the Federal investment in the FCRPS, including the
 25699 costs of mitigating the effects of the hydroelectric power system on fish and wildlife.

25700 Bonneville’s preference customers have expressed concern about the long-term
 25701 competitiveness of Bonneville’s wholesale power rates. These concerns prompted Bonneville to
 25702 take actions that will reduce its costs and change its 2009–2019 rate trajectory (power rates
 25703 increased by roughly 35 percent during this time). With these actions, Bonneville is now on a
 25704 sustainable rate trajectory. However, additional rate pressures that result from changes to the

25705 FCRPS that increase Bonneville’s costs, or reduce its revenues, would further challenge
25706 Bonneville’s new rate trajectory. Ultimately, significant additional rate pressure could
25707 overwhelm Bonneville’s ability to take corrective actions and could jeopardize Bonneville being
25708 the competitive supplier of choice for preference customers’ in the post-2028 period.

25709 The possibility that Bonneville’s traditional firm power customers (preference customers) may
25710 seek other suppliers because of the rising cost of Federal power presents important qualitative
25711 considerations for the power rate impacts discussed in the MOs (as well is in the analysis of the
25712 Preferred Alternative in Chapter 7). If preference customers choose to reduce their Federal
25713 power supply because of cost pressures, Bonneville would sell larger amounts of surplus power
25714 (firm and seasonal) into the wholesale power market and/or for periods up to 7 years as Excess
25715 Federal Power⁵² both within and outside the Pacific Northwest. These sales would likely occur
25716 at the prevailing market prices for power, which could be above or below Bonneville’s actual
25717 costs. Quantifying the revenue from these potential surplus sales of power is difficult because it
25718 is dependent on the amount of firm power requested by preference customers after 2028.

25719 Because of the difficulty with forecasting Bonneville’s future long-term sales, and the
25720 percentage of preference customers comprising these sales, this risk is presented as a
25721 qualitative risk. These qualitative considerations would include, among others, the ability of
25722 Bonneville to continue to fund major infrastructure. For example, if Bonneville must rely on
25723 surplus sales to recover its costs, which are an inherently more volatile source of revenue,
25724 Bonneville would have to become much more conservative when considering capital
25725 investments and potentially defer investments that otherwise would have been made per
25726 Bonneville’s asset management strategy. Bonneville also would likely be more cautious about
25727 committing to spending for fish and wildlife programs and other financial obligations beyond
25728 current budgets intended to maintain Bonneville’s current rate strategy. This follows from the
25729 limitations of selling Federal power at prevailing market prices, which may be below
25730 Bonneville’s fixed costs.

25731 Bonneville anticipates that sustained cost discipline between now and the expiration of power
25732 contracts in 2028 will help mitigate the risk of a substantial loss of firm power sales to
25733 preference customers due to competitive pressures. For this reason, the long-term
25734 competitiveness of Bonneville’s power rate is an important qualitative consideration that
25735 should be considered in conjunction with the rate pressures identified for each MO and the
25736 Preferred Alternative—particularly in alternatives with significant rate pressure.

25737 **3.7.3.2 No Action Alternative**

25738 This section evaluates power and transmission effects under the No Action Alternative.
25739 “No Action” represents continued operations, configuration, and maintenance of the system

⁵² The Energy and Water Development Act of 1996, Pub. L. 104-46, grants Bonneville the authority to market a category of surplus firm power, known as Excess Federal Power (firm power that is made surplus because regional firm power customers reject or abandon such power), to entities both within and outside the Pacific Northwest for a period of 7 years without having to recall such power to meet any requests from regional customers for firm power.

25740 under the operations rules in effect in September 2016. The analysis below projects generation
25741 and reliability of the regional power system through 2041. It accounts for planned maintenance
25742 at CRS projects in future years, load and resource forecasts, and planned retirements of coal
25743 power plants as of 2017 (i.e., base case assumptions).

25744 **CHANGES IN POWER GENERATION**

25745 Average power generation would minimally differ from current conditions. Average annual
25746 generation in the CRS is at 8,300 aMW (for reference, according to the NW Council, 1 aMW can
25747 power about 796 Northwest homes for a year). Several hydropower-generation statistics are
25748 useful in presenting effects to make comparisons between the No Action Alternative and the
25749 MOs. The first is monthly generation (Table 3-122) from the CRS projects, which peaks during
25750 high spring run-off and then decreases over the year through the fall. The second is peak- and
25751 heavy-load generation.⁵³ For the No Action Alternative, the annual average peak load period
25752 generation of CRS projects is 11,000 aMW, and the annual heavy-load period generation is
25753 8,800 aMW. Hydropower in the region (including CRS projects as well as other Federal and non-
25754 Federal projects) generates 13,000 aMW on average of the historical water years. Appendix H
25755 provides detailed generation results by project and for all water years modeled. Generation
25756 under critical water conditions (1937) for the CRS projects decreases by 300 aMW.

25757 **Table 3-122. 80-Year Average Monthly Average Electricity Generation (aMW) at the Columbia**
25758 **River System Projects under the No Action Alternative**

Month ^{1/}	NAA Generation (aMW)
October	5,600
November	7,400
December	8,300
January	9,500
February	9,700
March	8,800
April I	7,800
April II	8,200
May	10,000
June	11,000
July	8,800
August I	7,600
August II	6,500
September	5,800
CRS Annual Total	8,300

25759 1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these
25760 months tend to have substantial natural flow differences between their first and second halves. Estimates are
25761 rounded to two significant digits and may not sum to the totals reported due to rounding.

25762 Source: HYDSIM modeling results

⁵³ The peak-load period is defined as the highest 6 hours of a day, for 5 days a week, for 4 weeks a month. The heavy-load hour generation is from 6 a.m. to 10 p.m., Monday to Saturday.

25763 **EFFECTS ON POWER SYSTEM RELIABILITY**

25764 Based on load forecasts, limited coal plant retirements, and changes in power generation, the
25765 No Action Alternative would result in an LOLP of 6.6 percent in 2022. Although this exceeds the
25766 current NW Council target of 5 percent, the scope of the CRSO EIS analysis does not address the
25767 resources that might be needed to achieve the NW Council target under the No Action
25768 Alternative.⁵⁴ The scope of this EIS compares the MOs to the No Action Alternative.

25769 This LOLP estimate relies on an assumption about the resources available to serve regional
25770 loads over time that has changed since the initiation of this analysis. The basis for that
25771 assumption is the NW Council’s resource adequacy dataset developed in 2017. While it
25772 accounts for the planned coal plant closures known at that time, it also assumes coal plant
25773 generating capacity (4,246 MW) would continue to serve primarily regional IOU loads.

25774 Since the NW Council developed the dataset applied in this analysis, multiple additional or
25775 accelerated coal plant closure plans have been announced, as described in the Section 3.7.3.1
25776 above. Table 3-123 presents results of an analysis with updated assumptions on the level of
25777 coal capacity primarily available to serve regional IOU loads for power system reliability. The
25778 analysis considers two possible future conditions: (1) closure of most, but not all, coal plants
25779 given coal retirements announced and/or accelerated since 2017 (1,741 MW of coal remaining),
25780 and (2) complete removal of all coal capacity (0 MW of coal remaining). The analysis considers
25781 the effects of these assumptions on the LOLP and the annual fixed cost of a zero-carbon
25782 replacement portfolio (demand response, wind, solar, and storage [i.e., battery technology and
25783 pumped storage]) to restore power system reliability.

25784 This analysis finds that the power and transmission effects are very sensitive to assumptions
25785 regarding the coal generating capacity that would be available to serve regional loads. The coal
25786 plants are considered “base-load” resources and can be turned on or off (i.e., dispatchable) as
25787 needed to serve load. In contrast, intermittent resources like solar and wind under
25788 development in the region are not dispatchable, which means they may not be able to generate
25789 to meet demand. Even under the No Action Alternative, the LOLP levels are considerably higher
25790 with reduced generation from coal. With more limited coal-plant capacity, the LOLP is
25791 27 percent. Assuming that no coal capacity remains, and without resource development, this
25792 analysis finds that rolling blackouts would occur in the region in two out of every three years.

25793 While there may be additional means to maintain power system reliability over time
25794 (e.g., transmission infrastructure changes or new technologies), how this would be
25795 accomplished is uncertain. Appendix H includes a more detailed description of this analysis.

⁵⁴ Note that LOLP is a probabilistic estimate and does not indicate magnitude or scale of potential power system outages and it is also not linear in effects, however, it is a useful metric of overall power system reliability and stability. Furthermore, the NW Council’s target is not an enforceable standard. See NW Council Document Number 2011-14, Page 4, available at: https://www.nwcouncil.org/sites/default/files/2011_14_1.pdf (“The adequacy standard adopted by the NW Council does not mandate compliance or imply any enforcement mechanisms. It does not apply to individual utilities because each utility faces different circumstances. It is intended to be an early warning should aggregate regional resource development fall short, for whatever reason.”).

25796 The loss of baseload coal resources and replacement of those resources with new renewable
25797 resources, such as solar power, under these coal-closure scenarios changes the amount of
25798 additional resources needed to replace lost hydropower generation from the MOs compared to
25799 the No Action Alternative. Therefore, Table 3-123 shows a representative potential portfolio to
25800 give an idea of what might be needed to restore the LOLP of the No Action alternative to
25801 6.6 percent. The effects for each MO are discussed in their respective sections following this
25802 discussion of the No Action Alternative. For a sense of scale, the region currently has under
25803 1,000 MW of installed solar capacity both utility and small scale.

25804 **Table 3-123. Coal Capacity Assumptions, Zero-Carbon Replacement Resources for All Alternatives**

Alternative	Base Case Coal Capacity Assumption in EIS (4,246 MW)			More Limited Coal Capacity (1,741 MW)			No Coal Capacity (0 MW)		
	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Resource Build for the MO Relative to No Action (MW)	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Incremental Resource Build for the MO as Impacted by Additional Coal Retirement (MW)	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Incremental Resource Build for the MO as Impacted by Additional Coal Retirement (MW)
No Action	6.6%	0	0	27%	8,800	0	63%	28,000	0
MO1	11%	1,800	1,800	39%	9,300	0	69%	27,000	0
MO2	5.0%	0	0	16%	5,900	0	49%	22,000	0
MO3	14%	2,850	2,850	43%	13,000	1,350	79%	35,000	4,150
MO4	30%	5,600	5,600	55%	12,000	0	81%	30,000	0

25805 Notes: The replacement resources for the No Action Alternative include demand-response, wind, and solar; for MO3, the analysis additionally includes storage
25806 technology (e.g., batteries, pumped storage). The incremental resource builds under the more limited coal capacity or no coal capacity are additive with the
25807 resource builds under the base case.

25808 **POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS**

25809 Given the key assumptions described above for the base case analysis (including continued coal
25810 capacity), the analysis finds that no replacement resources would occur under the No Action
25811 Alternative, though higher than the NW Council's standard of 5 percent, the 6.6 percent LOLP is
25812 within the reasonable historical range of the NW Council target.

25813 Note the coal capacity analysis only analyzes the effects from limited to no coal capacity on the
25814 LOLP and the potential size of a zero-carbon replacement. The analysis of rate effects presented
25815 below relies on the base case assumptions without the additional coal plant retirements.
25816 The detailed analysis does not address the additional generation balancing reserves needed to
25817 integrate large amounts of new renewable resources but does add an estimate of this value to
25818 the calculation of the rate pressure. Generation balancing reserves allow grid operators to
25819 increase or decrease generation in response to changes in load and generation to ensure
25820 instantaneous balance between load and generation. The generation output of renewable
25821 resources is more variable (subject to sudden changes in the weather) and requires more
25822 generation balancing reserves to balance load and generation levels. In this analysis, the
25823 generation balancing reserves needed for the No Action Alternative are included in all
25824 modeling. However, the additional reserves needed if large amounts of renewable resources
25825 (such as wind and solar) are added have not been addressed. These reserves can be supplied
25826 through the hydropower system if the system has enough flexibility, or from gas-fired
25827 generators in the region. With further technological advances and substantial increases in
25828 power storage capacity, other options may be available in the future. Based on the outcome of
25829 this EIS, if Bonneville requires additional generation balancing reserves, it would evaluate how
25830 to acquire these resources in a separate process or processes (that would include appropriate
25831 NEPA review) subsequent to the CRSO EIS process.

25832 For the scenario with the more limited coal capacity, the LOLP of the No Action Alternative rises
25833 to 27 percent. This value would represent having power shortages in nearly one of every three
25834 years and would require the region to acquire new resources to replace the coal generation.
25835 While the scope of the CRSO EIS analysis is not necessarily to address resource adequacy issues
25836 related to the No Action Alternative because the coal-plant retirements are not serving Federal
25837 load, resource acquisitions made by the region for the coal-plant retirements will affect how
25838 changes in CRS hydropower would impact the region. Therefore, for the scenarios with more
25839 limited or no coal capacity, the CRSO EIS estimated the amount of zero-carbon resources that
25840 would be needed to return the LOLP of No Action alternative to the level before the additional
25841 coal plant retirements, i.e., to 6.6 percent. If the retired coal capacity is replaced with natural
25842 gas power plants, then it would take about the same amount of new gas plant capacity as the
25843 amount of retired coal capacity. However, because the regional policy and legislative direction
25844 is not to build new carbon-emitting resources, the EIS examined what the resource build might
25845 be for zero-carbon replacement resources. As shown in Table 3-123 for the case with more
25846 limited coal capacity, the region would need about 8,800 MW of new zero-carbon resources;
25847 for the case with no coal capacity, the region would need about 28,000 MW of new zero-carbon
25848 resources.

25849 When baseload resources are replaced by intermittent resources such as wind and solar
25850 generation, the nameplate capacity of the replacement resources must be higher than the
25851 capacity of the baseload resource that is retired. This stems from two similar effects.
25852 On average, an intermittent resource generates less than its nameplate capacity because it is
25853 not always windy and sunny. Furthermore, an intermittent resource does not generate its
25854 average output at all times, is seasonal in nature, and is often generating less (or nothing) at
25855 times of greatest need. Thus, the intermittent resources that replace baseload resource
25856 capacity need to have greater nameplate capacity than the baseload resource they are
25857 replacing to meet all of the demand. This is why in the No Action Alternative, the zero-carbon
25858 resource builds in Table 3-132 are much higher than the amount of coal retirement in the two
25859 scenarios. In the Pacific Northwest, the hydropower system can often reduce generation when
25860 wind and solar generation are abundant and increase generation when wind and solar are not
25861 generating as much. Without the hydropower flexibility, the region would probably need even
25862 more zero-carbon resource builds to replace the retired coal generation. Operating constraints
25863 on the hydropower system limit the extent to which hydropower generation can adjust to
25864 complement wind and solar generation.

25865 **BONNEVILLE FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION PLAN**
25866 **COSTS**

25867 The summary rate table for the Base Case analysis includes an estimate of approximately \$339
25868 million in annual costs for the Fish and Wildlife Program and LSRCP combined for the No Action
25869 Alternative. In 2016, the Bonneville Fish and Wildlife Program spending level was \$267,000,000
25870 and the LSRCP spending level was \$32,303,000 (BP-16 Rate Case). Adjusted to 2019 dollars,
25871 these spending levels are \$281,536,000 and \$34,062,000, respectively.

25872 **EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE**

25873 **Bonneville Transmission System Interconnections, Reliability, and Operations**

25874 Under the No Action alternative, Bonneville would continue to maintain transmission system
25875 reliability by providing proper voltage for delivery of energy to expected loads in the 10-year
25876 planning horizon (and beyond) while keeping transmission loadings within required limits. Thus,
25877 the analysis did not identify any additional Bonneville transmission capital costs or transmission
25878 system reliability issues under the No Action Alternative beyond those activities that Bonneville
25879 already identifies in its regular system assessments. Due to expected increases in loads in the
25880 Tri-Cities load service area, Bonneville's regular system assessments have identified several
25881 transmission reliability projects that are anticipated to occur within and beyond the 10-year
25882 planning horizon.

25883 **Regional Transmission System Congestion Effects**

25884 Under the No Action Alternative, nine regional transmission paths would experience some
25885 hours of congestion at some point in the year in at least one direction under the various flow
25886 conditions.

25887 The greatest number of congested hours under the No Action Alternative would occur on the
25888 Hemingway to Summer Lake transmission path. This path would have 1,412 hours of west-to-
25889 east congestion in the high-runoff case due to increased hydro generation. The Hemingway to
25890 Summer Lake path contains one transmission line (the Hemingway to Summer Lake
25891 transmission line). The Idaho to Northwest transmission path, which consists of five high-
25892 voltage transmission lines in Idaho and Oregon including the Hemingway to Summer Lake
25893 transmission line, also exhibits west-to-east congestion during median and high runoff cases.⁵⁵

25894 Congestion would also occur on five paths that can exhibit congestion in the north-to-south
25895 direction depending on flow patterns. The Pacific DC Intertie, which runs through Oregon to the
25896 Oregon/Nevada border (where the Bonneville owned portion ends) and continues to the Los
25897 Angeles area under non-Bonneville ownership, would experience the highest frequency of
25898 congestion, accounting for between 442 and 620 hours of the north-to-south annual congestion
25899 hours. This congestion forecast is likely conservative because it estimates a highly optimized
25900 power system and does not account for unplanned outages, maintenance, or other
25901 circumstances that affect the transmission system and may result in congestion. Thus, if an
25902 unplanned outage, routine maintenance, or other circumstances occurred, the effects to
25903 congestion would be greater than described above

25904 Transmission system reliability is expected to be maintained under the No Action Alternative
25905 despite congestion on these paths. Detailed graphs depicting the number of hours of
25906 congestion along the individual paths under different water years appear in Appendix H.

25907 **ELECTRICITY RATE PRESSURE**

25908 As explained below, the No Action Alternative analysis identifies that potential rate pressure
25909 over time would be in line with recent trends.

25910 **Bonneville Wholesale Power Rates**

25911 Based on the modeled rate pressures under the No Action Alternative, the average wholesale
25912 rate for firm power may be around \$34.56 per MWh in 2019 dollars. This represents the
25913 average rate paid by Bonneville's preference customers in the No Action Alternative and not
25914 the effective rate paid by a particular Bonneville customer⁵⁶ nor is it the actual or forecast rate
25915 in Bonneville rate cases.

25916 **Market Prices**

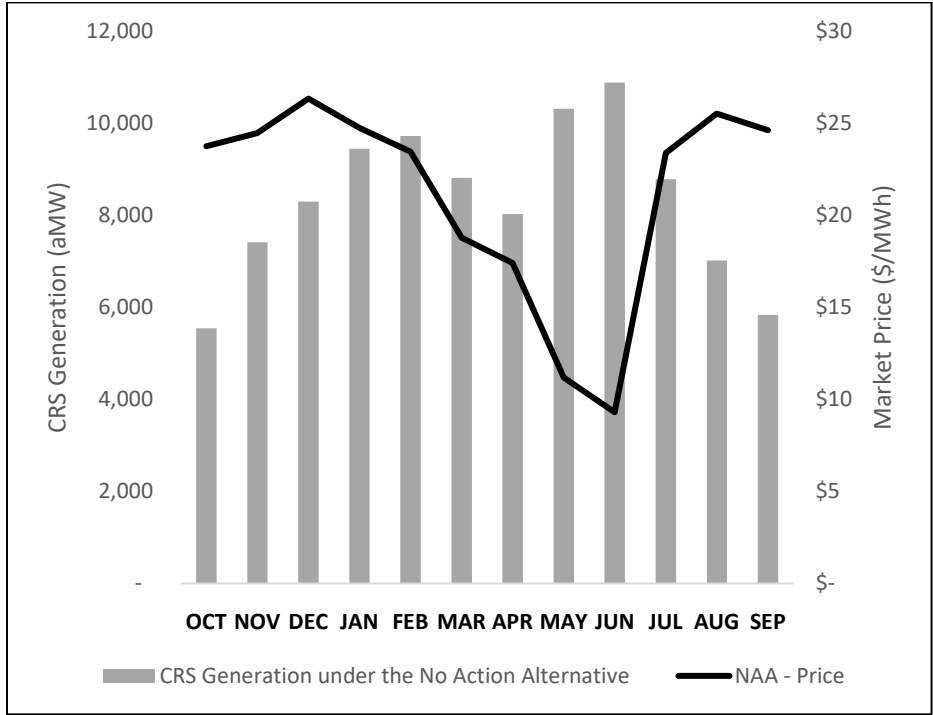
25917 Estimated average exports would amount to roughly 910,000 MWh (190 aMW) of sales during
25918 periods of high load (i.e., referred to as "heavy load hours"⁵⁷) and 400,000 MWh (100 aMW) in

⁵⁵ The Hemingway to Summer Lake and Idaho to Northwest transmission paths are not operated and managed by Bonneville.

⁵⁶ The effective rates paid by each customer are different due to the specifics of a particular customer, such as its load profile and the products and services it purchases from Bonneville.

⁵⁷ Heavy load hours are Monday through Saturday hour ending 7 through 22 (i.e. 6 am to 10 pm), excluding NERC holidays.

25919 light load hours⁵⁸ per month. The average price for power traded at the Mid-Columbia trading
 25920 hub is forecast to be \$21.02 per MWh for heavy load hours and \$16.66 per MWh for light load
 25921 hours (2019 dollars). The overall average market price would be \$19.42 per MWh (2019
 25922 dollars). This value would fluctuate throughout the year in relation to streamflow, generation,
 25923 demand, and market factors. Figure 3-175 shows the average market price and average Federal
 25924 hydropower generation by month.



25925

25926

25927 **Figure 3-175. Monthly CRS Generation (aMW) and Market Price (\$/MWh)**

25928 Note: The right axis is the market price (\$/MWh). The left axis is generation from the CRS projects by month
 25929 (aMW). Source: Power Analysis 2019.

⁵⁸ Light load hours are Monday through Saturday hour ending 23 through 6 (i.e. 10 pm to 6 am), including NERC holidays, and all day on Sundays.

25930 It is important to note the difference in value between wholesale spot market prices and
25931 Bonneville's wholesale power rates. Power traded in the spot market is often between
25932 marketers and utilities and is generally surplus to a utility's needs or produced by a merchant
25933 plant owned by an independent power producer. Bonneville trades in the spot market,
25934 meaning that it purchases power and sells its surplus power when available and economical to
25935 do so. The revenues from Bonneville's surplus sales and purchases are credited back to its
25936 wholesale power rates. However, the product sold at spot market prices is not the same as the
25937 product sold at Bonneville's wholesale power rates. The spot market cannot be counted on as
25938 being available on a guaranteed long-term basis, it does not follow load, and does not include
25939 many other attributes found in Bonneville's wholesale power products (*e.g.*, low-carbon,
25940 energy loss returns, an energy efficiency incentive, scheduling). When customers buy power
25941 from Bonneville under firm, long-term contracts, they receive these other attributes and are
25942 assured that Bonneville will supply them with the power they need. Consequently, the power
25943 product Bonneville sells to its preference customers under long-term power sales contracts has
25944 higher value (and can have a higher average cost) than the power products sold in the spot
25945 market.

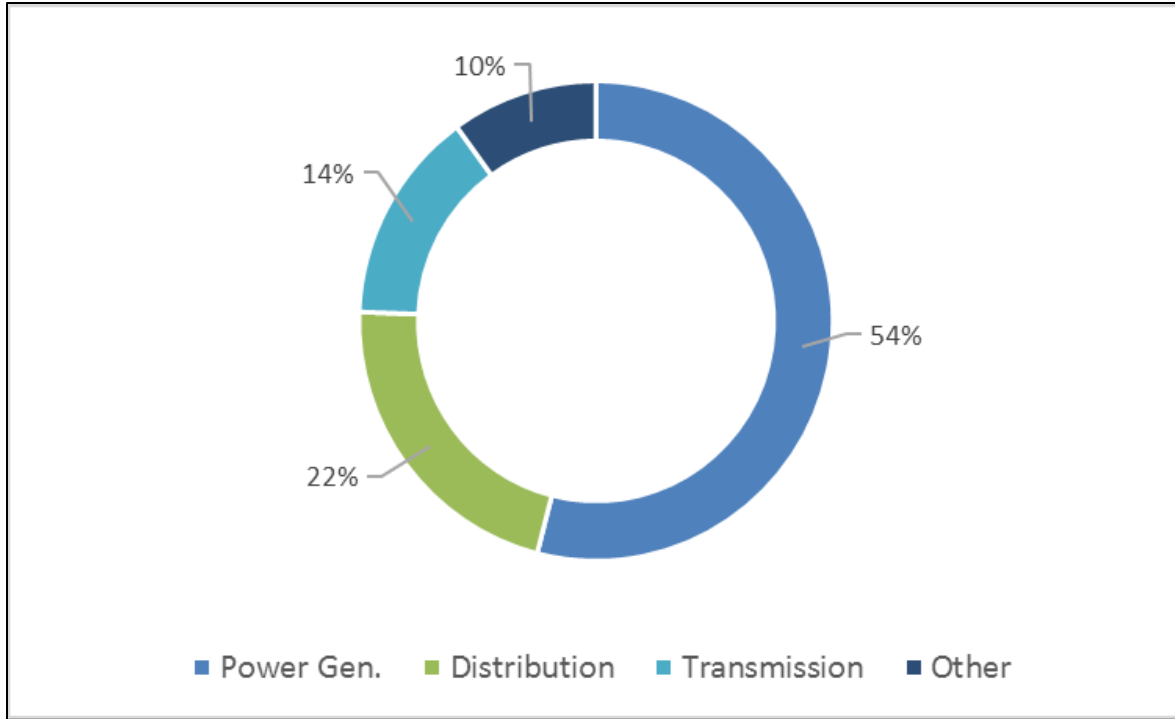
25946 In addition, it is important to note that the Pacific Northwest is currently experiencing
25947 historically low natural gas prices. These prices are currently forecasted to remain low. As such,
25948 this analysis may underestimate energy costs should natural gas prices increase in the future.

25949 **Bonneville Wholesale Transmission Rate Pressure**

25950 Under the No Action Alternative, there would be no changes assumed in capital investments or
25951 in transmission sales compared to the current 8-year baseline (through 2029). Therefore, the
25952 Bonneville transmission wholesale rates would not likely deviate from current long-term
25953 conditions, meaning no additional transmission rate pressure attributable to the No Action
25954 Alternative.

25955 **Retail Rates**

25956 Under the No Action Alternative in 2022, based on the modeled rate pressure, the estimated
25957 average regional residential, commercial, and industrial retail rates for the region would be
25958 10.21, 8.89, and 7.25 cents per kWh, respectively. These estimates are derived from unbundling
25959 the retail rate into key components: power generation, distribution, transmission, and other
25960 administrative costs. Figure 3-176 provides an example of this disaggregated retail electricity
25961 rate based on 2016 data from financial reports at FERC compiled by the EIA. The analysis of the
25962 transmission rate pressure effects for each alternative relies on this data for the portion of
25963 historical retail rates attributable to transmission.



25964
 25965 **Figure 3-176. Breakdown of an Average Retail Electricity Rate by Component**
 25966 Source: EIA (2016, 2019)

25967 Table 3-124 presents the average retail rates across counties for residential, commercial, and
 25968 industrial end users in the area of analysis under the No Action Alternative. The residential
 25969 retail rate in counties across the Pacific Northwest, reflecting the full set of power customers
 25970 across the Pacific Northwest, would range from 2.97 to 13.42 cents per kWh.

25971 **Table 3-124. Weighted Average 2022 Estimated Retail Rates (cents per kWh), 2019 U.S.**
 25972 **Dollars**

Estimated Retail Electricity Rate	Residential	Commercial	Industrial
Average	10.21	8.89	7.25
Maximum	13.42	12.01	17.18
Minimum	2.97	2.91	2.29

25973 **SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION**

25974 **Social Welfare Effects**

25975 As previously described, social welfare effects are estimated based on two methods: the
 25976 market price method, which calculates changes in the market value of the changes in
 25977 hydropower generation, and the production cost method, which quantifies the incremental
 25978 costs of providing power under each alternative. As a baseline for these methods, average
 25979 annual generation from Pacific Northwest hydropower under No Action is 13,000 aMW
 25980 (equivalent to 120,000,000 MWh) under the base case.

25981 **Regional Economic Effects**

25982 Table 3-125 summarizes the estimated average monthly consumption and bills by end user type
25983 under the No Action Alternative.

25984 **Table 3-125. Average Consumption and Monthly Bills for Each End-User Group under the No**
25985 **Action Alternative, 2019 U.S. Dollars**

End-User Group	Average Consumption	Average Monthly Bill
Residential	1,000 kWh/month	\$90
Commercial	5,000 kWh/month	\$500
Industrial	50,000 kWh/month	\$4,800

25986 Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

25987 The retail rate forecast considers the NW Council’s economic forecast for both growth in
25988 electricity rates for ratepayers over time, as described for residential end users in Table 3-126,
25989 and growth in load per household and for commercial and industrial end users. The No Action
25990 analysis relies on these forecasts to evaluate the socioeconomic effects over time.

25991 **Residential Effects**

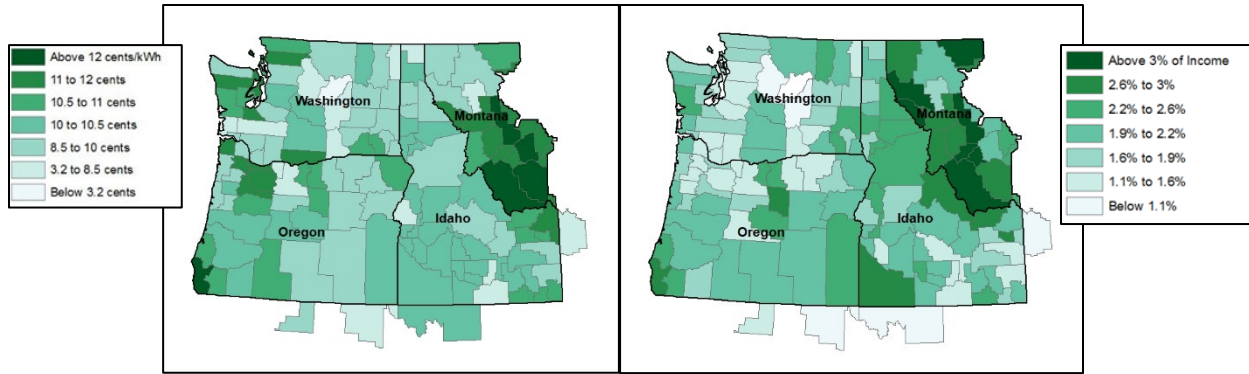
25992 Retail electricity rates would remain relatively low (some increases after 2028) and loads
25993 relatively flat (NW Council 2017, 2019). Table 3-126 presents the average forecasted residential
25994 retail rate from 2022 to 2040 (including 2022, and then in five-year increments from 2025).

25995 **Table 3-126. Average Residential Retail Rate (cents per kWh, 2022 to 2040), 2019 U.S. Dollars**

Average Estimated Retail Rate	2022	2025	2030	2035	2040
High (1% annual growth)	10.21	10.36	10.88	11.43	12.00
Medium (-0.7% annual growth)	10.21	10.00	9.66	9.33	9.02
Low (-1% annual growth)	10.21	9.77	9.30	8.85	8.43

25996 Figure 3-177 presents geographic effects of the rates and expenditures across Pacific Northwest
25997 counties in 2022. Darker shading represents higher average rates and expenditures as a
25998 percentage of income. Electricity rates for residential end users would be highest in areas of
25999 Montana with certain counties of Oregon and Washington experiencing higher rate than the
26000 regional average. Rates are typically higher in Montana than the other states in the region and,
26001 despite slightly lower consumption of electricity, the higher rates coupled with slightly lower
26002 median income levels result in higher-than-average spending on electricity, consistent with
26003 existing conditions (EIA 2018a; NW Council 2015).

26004 The rates would be higher in rural counties not adjacent to metropolitan areas, where the
26005 average residential retail rate would be between 9.84 and 13.42 cents per kWh. In metropolitan
26006 areas with populations above 250,000 residents, average residential retail rates would be
26007 lower, ranging from 7.11 to 11.44 cents per kWh.



26008
26009 **Figure 3-177. Average Residential Retail Rates in Cents per kWh (left) and Percentage of**
26010 **Household Income Spent on Electricity (right).**

26011 Over time, retail electricity rates would decrease in real terms (i.e., adjusted for inflation) while
26012 demand for electricity remains relatively flat (NW Council 2016, 2019). Table 3-127 lists the
26013 average annual household expenditures on electricity over a 20-year time period across the
26014 Pacific Northwest. The rates, and resulting household electricity expenditures, would decrease
26015 over time under the No Action Alternative until 2028 due to the rate decreases and relatively
26016 flat demand growth described in Table 3-126.

26017 **Table 3-127. Average Annual Expenditures on Electricity, 2019 U.S. Dollars**

Estimated Annual Expenditures	2022	2025	2030	2035	2040
High	1,100	1,000	990	1,000	970
Medium	1,100	950	810	760	670
Low	1,000	900	740	660	580

26018 Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

26019 Using median household income by county, this analysis estimates the percent of income spent
26020 on electricity per household (Table 3-128). The percentage of electricity, on average, would be
26021 1.7 percent of median household income. This ratio fluctuates based on county income levels
26022 with lower income levels spending more on electricity. Figure 3-177 shows the geographic
26023 breakdown of the percentage of income spent on electricity by county. The highest percentage
26024 of expenditures occurs in a single county (Glacier County, Montana) with 4.1 percent. Over
26025 time, because income would increase more than the estimated retail rates, the portion of
26026 income spent on electricity would decrease over time for all load and rate growth rates. Given
26027 considerable uncertainty around future load and rate changes over time, the analysis considers
26028 three potential growth rates (high, medium and low).

26029 **Table 3-128. Average Percent of Median Household Income Spent on Electricity (percent of**
26030 **median household income)**

Percent of Income Spent on Electricity	2022	2025	2030	2035	2040
High	1.7%	1.5%	1.2%	1.0%	0.87%
Medium	1.7%	1.4%	1.0%	0.84%	0.65%
Low	1.7%	1.4%	1.0%	0.81%	0.61%

26031 **Commercial and Industrial Effects**

26032 Commercial and industrial end users also experience increasing rates over time under the No
26033 Action Alternative.⁵⁹ The retail rates would be on average 8.89 cents per kWh for commercial
26034 end users and 7.25 cents per kWh for industrial end users across the Pacific Northwest.
26035 As described in Table 3-124, these rates vary by county with higher and lower retail rates.

26036 These end-user groups consume far more electricity than households every year, paying large
26037 monthly bills for electricity use, thus their usage under the No Action Alternative would reflect
26038 this. On average, commercial end users would pay \$5,900 per year on electricity—a \$500
26039 monthly bill. Unlike residential load, industrial load would increase over time for the majority of
26040 industrial end users and some commercial end users (NW Council 2016). Consistent with NW
26041 Council forecasts, demand for electricity under the No Action Alternative would decrease in
26042 Idaho for industrial users while increasing in all other states. Similarly, Washington would
26043 experience decreases in load for commercial end users while all other states would experience
26044 small increases. By 2040, the average expenditures on electricity for commercial end users
26045 would decrease slightly to \$5,400 annually (\$450 monthly). Industrial end users average annual
26046 bills would remain relatively constant, from \$48,000 to \$50,000 by 2040, with increasing load
26047 but decreasing rates.

26048 Table 3-129 presents the forecast of average annual expenditures on electricity for commercial
26049 and industrial consumers.

26050 **Table 3-129. Annual Expenditures for Commercial and Industrial End Users under the No**
26051 **Action Alternative, 2019 U.S. Dollars**

Average Annual Expenditures	2022	2025	2030	2035	2040
Commercial	5,900 (5,700 to 6,200)	5,800 (5,500 to 6,400)	5,700 (5,200 to 6,900)	5,500 (4,800 to 7,400)	5,400 (4,600 to 7,900)
Industrial	48,000 (46,000 to 50,000)	48,000 (46,000 to 53,000)	49,000 (45,000 to 59,000)	50,000 (45,000 to 66,000)	50,000 (45,000 to 74,000)

26052 Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

26053 For industrial end users, the NW Council forecasts the total revenue generated by that sector—
26054 in 2022, it would be \$140 billion. Total industrial expenditures on electricity would be \$5.1
26055 billion, which equals 3.5 percent of total industrial revenues.

⁵⁹ Industrial and commercial end users are found across the region; however, there are concentrations of business activity in certain areas. Specifically, more urban areas such as King, Snohomish, Pierce, and Multnomah Counties, which contain the cities of Seattle, Tacoma, and Portland, respectively, include the two largest concentrations of commercial and industrial end users. These counties collectively represent 35 percent of all commercial businesses, and thus also represent much of the demand for power from commercial end users in the region.

26056 **Other Social Effects**

26057 Some households use more electricity and thus spend more relative to others. There is the
26058 potential for households to experience energy insecurity (e.g., inability to use heating or cooling
26059 equipment or reducing food or medicine to pay for energy costs) should electricity rates
26060 increase (EIA 2018a). Additionally, health and safety concerns may arise during blackouts when
26061 certain services are not available (operation of medical devices or safety equipment). Under the
26062 No Action Alternative, expenditures on residential electricity are consistent with recent trends
26063 that would be unlikely to create conditions for energy insecurity. Expected income growth and
26064 low load growth indicates that expenditures on energy as a percent of income, in fact, decrease
26065 over time (EIA 2018a; NW Council 2019). Similar to rates, power and transmission system
26066 reliability under the No Action Alternative is similar to current trends and would not increase
26067 the frequency of outage events so no health and safety effects would be expected.

26068 **SUMMARY OF EFFECTS**

26069 The generation of the CRS projects and the Federal system would remain similar to recent
26070 history. Wholesale power and transmission rates would continue to increase slowly over time.
26071 Combined with increasing median household incomes and relatively slow load growth,
26072 spending on electricity as a percentage of income would decrease over time.

26073 In the scenarios with limited or no coal generation in the future, the CRSO EIS analysis assumes
26074 that regional entities would acquire additional resources to replace the coal-based generation
26075 to maintain power system reliability. If these resources are not acquired, then the region would
26076 experience substantial reliability risks. These scenarios provide an approximation of effects
26077 based on current information. The decision whether or not resources are built, what type of
26078 resources are built, and when resources are built influence the analysis of effects of the MOs
26079 relative to the No Action Alternative, so certain assumptions were made to estimate these
26080 potential effects. If a Federal decision was made that substantially affected reliability,
26081 additional NEPA analysis would likely be needed to determine how to address these effects
26082 (Table 3-130).

26083 **Table 3-130. Summary of Effects under the No Action Alternative without Additional Coal**
26084 **Plant Closures**

Effect	No Action Alternative
CRS Hydropower Generation (aMW)	8,300
Firm Power Generation from FCRPS (aMW) ⁶⁰	7,100
LOLP	6.6%
Average Bonneville Wholesale Power Rate (\$/MWh)	\$34.56
Average Residential Rate (cents/kWh)	10.21
Commercial Rate (cents/kWh)	8.89
Industrial Rate (cents/kWh)	7.25

⁶⁰ The amount of firm power Bonneville expects to have for marketing from Federal dams to meet its obligations under long-term firm power sales contracts is calculated based on modeling a hydro forecast that uses “critical water year,” the most adverse historical streamflow year on record.

26085 **3.7.3.3 Multiple Objective Alternative 1**

26086 This section evaluates effects under MO1. Overall, hydropower would decrease relative to the
26087 No Action Alternative under MO1; therefore, the analysis accounts for potential replacement
26088 resources that would maintain LOLP at No Action Alternative levels. The effects of decreased
26089 hydropower generation and the need for replacement resources would result in slight upward
26090 rate pressure under MO1 relative to the No Action Alternative.

26091 **CHANGES IN POWER GENERATION**

26092 Table 3-131 and Figure 3-178 present the generation for No Action and MO1 and their
26093 differences by month. Overall, generation from the CRS projects would drop from 8,300 aMW
26094 under the No Action alternative, on average, over all water years, to 8,200 aMW under MO1.
26095 This represents a decrease of 130 aMW, ⁶¹ which is a 1.6 percent decrease in generation on
26096 average. The reduction in critical water generation from MO1 is even greater. (The decrease in
26097 generation from all Northwest U.S. projects including the non-Federal projects that are affected
26098 by changes in the CRS projects is -170 aMW.) The critical water year generation of the CRS
26099 projects would decrease by 5 percent (300 aMW), and the amount of firm power used to supply
26100 Bonneville’s long-term contracts would decrease by 300 aMW.

26101 **Table 3-131. Monthly Electricity Generation at the Columbia River System Projects under**
26102 **Multiple Objective 1, in aMW**

Month ^{1/}	NAA	MO1 Generation Difference	MO1 % Difference
October	5,500	-57	-1.0%
November	7,400	-10	-0.1%
December	8,300	-170	-2.0%
January	9,500	180	1.9%
February	9,700	14	0.1%
March	8,800	-100	-1.2%
April I	7,800	-280	-3.5%
April II	8,200	-430	-5.2%
May	10,000	-470	-4.5%
June	11,000	-95	-0.9%
July	8,800	-170	-1.9%
August I	7,600	-650	-8.6%
August II	6,500	-340	-5.3%
September	5,800	150	2.5%
Annual Average	8,300	-130	-1.6%

26103 Notes: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
26104 HYDSIM modeling inadvertently omitted the impact of the *Winter System FRM Space* in December of some years,
26105 which would move some generation (0 to 450 MW depending on the year) from January into December. This
26106 operation would not change the conclusions of the analysis.

⁶¹ Numbers are rounded to two significant digits, so sums and differences might not match the original numbers exactly.

26107 1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these
26108 months tend to have substantial natural flow differences between their first and second halves.
26109 Source: HYDSIM modeling results

26110 The three measures that appear to have the largest impact on generation are the *Lake*
26111 *Roosevelt Additional Water Supply*, *Block Spill Test (Base + 120/115%)*, and *Modified Dworshak*
26112 *Summer Draft*. The additional water supply reduces generation throughout the spring and
26113 summer. The MO1 spill regime decreased generation in the spring as spill was increased
26114 compared to No Action. The changes in flow at Dworshak increased June, July, and September
26115 generation but caused a large reduction. The reduction in August generation in MO1 is
26116 substantial enough to lead to loss-of-load events in August, particularly in the first half of the
26117 month before summer spill ends. In the No Action Alternative, generation in August is sufficient
26118 to ensure that there are few substantial loss-of-load events.

26119 While the change in generation would not be large on average across the year, the effect on
26120 LOLP would be larger due to the timing within the year of when the generation decreases are
26121 forecast to occur. Modeling results showed that generation would primarily decrease in
26122 December (largely due to the change in end-of-December elevation at Libby), the spring (largely
26123 due to increases in spill), and late summer (largely due to the change in timing of flows from
26124 Dworshak and increases in irrigation). There would be increases in January and February (from
26125 Libby starting January at a higher elevation). Because late summer and winter carry the highest
26126 probability of generation insufficiency, the relatively larger decreases in generation in August
26127 and December would have a greater impact on LOLP than might otherwise be expected given
26128 the annual average reduction in CRS generation is limited to 130 aMW and generation on the
26129 Northwest U.S. system including non-Federal projects decreases by 170 aMW.

26130 The ability of CRS projects to meet peak- and heavy-load periods would decrease by 1 percent
26131 and 4 percent, respectively, relative to the No Action Alternative. Based on a qualitative
26132 assessment of the alternative, some measures in MO1 would slightly increase the flexibility of
26133 operating the CRS projects while other measures would slightly decrease the flexibility affecting
26134 the ability to integrate other renewable resources into the power grid.

26135 Other non-Federal regional hydropower projects that are located downstream of CRS projects
26136 (such as the Mid-Columbia hydro projects) would experience similar trends as the CRS projects
26137 in the winter from flow changes upstream of these projects. However, the projects would not
26138 be affected by the changes in fish passage spill in MO1 or flow changes at Dworshak in late
26139 summer. The regional generation including these non-Federal projects would be on average
26140 13,000 aMW, which is a decrease of approximately 1 percent (170 aMW) relative to the No
26141 Action Alternative (at 13,000 aMW). The CRS projects account for 130 aMW of the 170 aMW
26142 decrease under MO1.

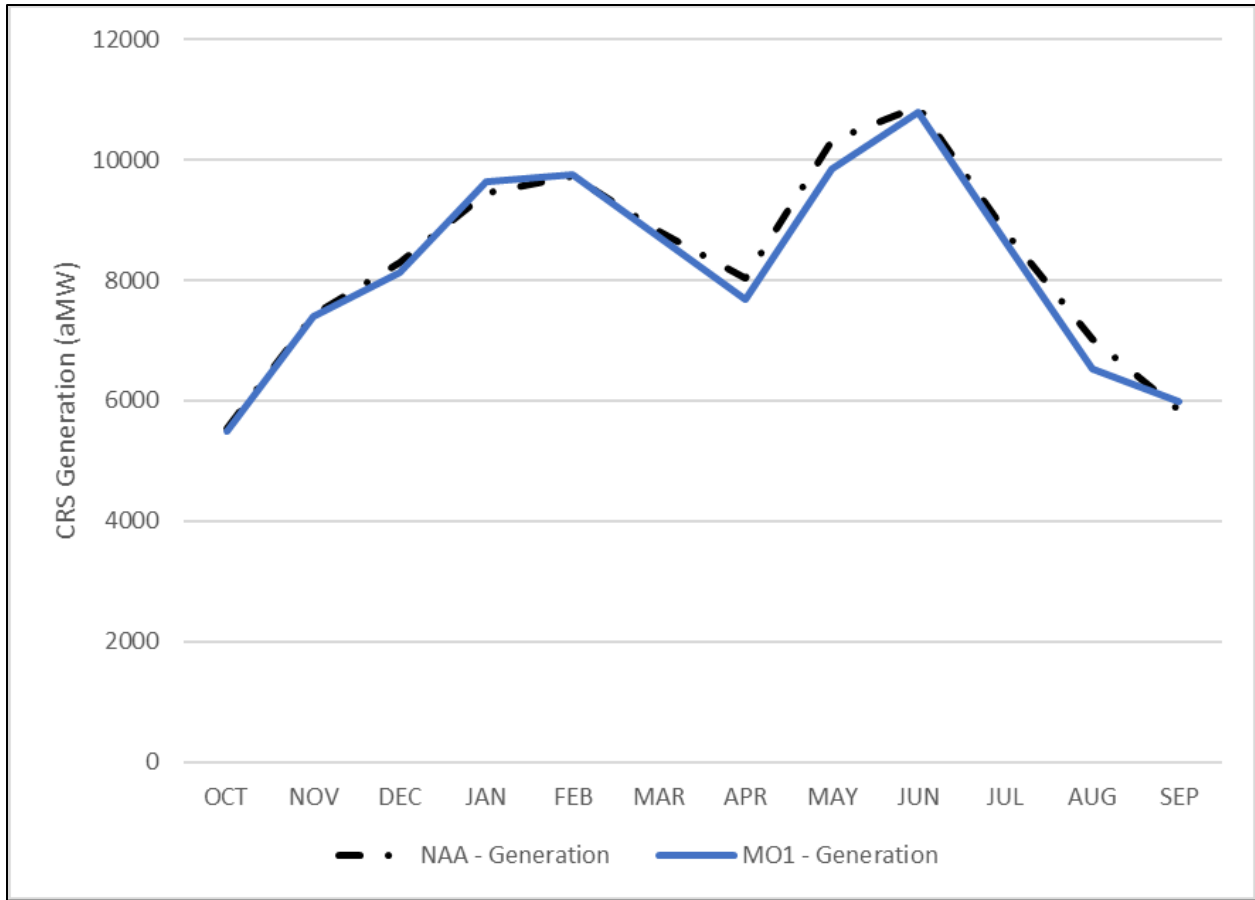


Figure 3-178. Monthly Hydropower Generation at the CRS Projects, No Action Alternative and Multiple Objective 1, in aMW, for the Base Case without Additional Coal Plant Retirements

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EFFECTS ON POWER SYSTEM RELIABILITY

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Due to the reduction in total hydropower generation under MO1, the LOLP would be 11.2 percent, 4.6 percentage points higher than the LOLP in the No Action Alternative, which has an LOLP of 6.6 percent. This increased LOLP comes from changes in the summer generation when demand for electricity is relatively high and because MO1 reduces generation capacity when generation is already relatively low. An 11.2 percent LOLP is roughly equivalent to a one-in-nine likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) in 2022. In percentage terms, this represents a nearly 70 percent increase in the likelihood of blackouts when compared to the No Action Alternative.

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As described in Section 3.7.3.2, these LOLP estimates rely on the assumption that 4,246 MW of coal generating capacity would continue to serve regional loads (primarily IOU loads, not public utility loads) over the study period. The LOLP for No Action (6.6 percent) without the additional coal retirements is already above the NW Council target of 5 percent. And the difference between MO1 and the No Action Alternative is larger in the two scenarios with the additional coal closures than in the base analysis due to the loss of baseload resources with the retirement of additional coal plants. As these coal plants retire, the LOLP of the region will increase for the

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26162 No Action Alternative and for MO1. However, the increase will not be the same for the two
26163 alternatives. Regional utilities and Bonneville trade power with each other (hourly, daily,
26164 monthly and longer) depending on when a utility is surplus or deficit because of seasonal and
26165 shorter variations in demand for power and variations in supply (e.g. water availability
26166 impacting hydropower generation). As operations and power generation change between the
26167 No Action Alternative and MO1, the seasonality of when Bonneville may rely on generation
26168 from non-federal sources to meet load will change. Thus, when coal-plants are retired, their
26169 impact on reliability would be different depending on the seasonality of generation losses in the
26170 No Action alternative versus that of MO1. LOLP is not linear in part due to the complex
26171 seasonally varying interactions between generation and load in the region. In future scenarios
26172 with limited coal capacity, the LOLP under MO1 would increase by 12 percentage points
26173 compared to the No Action Alternative. In other words, this would result in absolute LOLP
26174 percentage values of 39 percent in a limited coal capacity scenario (whereas No Action is 27
26175 percent). The non-linearity of LOLP manifests itself further in the no-coal scenario; the LOLP
26176 under MO1 would be 6 percentage points higher than the LOLP of the No Action Alternative,
26177 with an absolute LOLP of 69 percent without any regional coal capacity (whereas No Action is 63
26178 percent) . Table 3-132 summarizes these LOLP values.

26179 **Table 3-132. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 1 Relative to the No**
26180 **Action Alternative**

Alternative	Base Case Coal Capacity Assumption in EIS (4,246 MW)			More Limited Coal Capacity (1,741 MW)			No Coal Capacity (0 MW)		
	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Resource Build Relative to No Action (MW)	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Incremental Resource Build for MO1 as Impacted by Additional Coal Retirement (MW)	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Incremental Resource Build for MO1 as Impacted by Additional Coal Retirement (MW)
No Action	6.6%	0	0	27%	8,800	n/a	63%	28,000	n/a
MO1	11%	1,800	1,800	39%	9,300	0	69%	27,000	0

26181 Notes: The replacement resources for the No Action Alternative include demand-response, wind, and solar; for MO1 the analysis additionally includes storage
26182 (e.g., batteries, pumped storage). The incremental resource builds under the more limited coal capacity or no coal capacity scenarios are additive with the
26183 resource builds under the base case, so the total effect is 1,800 MW of build in all three scenarios.

26184 **POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS**

26185 To maintain power system reliability in the Northwest, additional generation resources and
26186 transmission facilities would be needed under MO1. However, construction of new resources
26187 (e.g., gas, solar, wind, or pumped storage) and new transmission can easily take a decade to
26188 bring online given the time needed for planning, permitting, land acquisition, and physical
26189 construction. Setting aside the timing of construction, under the least-cost replacement
26190 generation portfolio, returning LOLP to the No Action Alternative level would require about
26191 560 MW of single-cycle natural gas turbines.⁶² (The transmission analysis assumes these would
26192 be located in the northeastern Oregon area, which would optimize accessibility to gas pipeline
26193 and transmission capacity.) This portfolio would cost \$27 million annually, including annualized
26194 capital costs, fixed operations and maintenance, and insurance (2019 dollars). This figure does
26195 not include the annual cost of fuel to generate power, nor variable operation and maintenance
26196 costs, which would vary depending on annual power production. During critical water
26197 conditions, the fuel cost plus variable costs would be roughly \$16 million annually (2019
26198 dollars). The decision on the exact resources to be built in the region would ultimately be made
26199 incrementally by various regional parties. The Socioeconomic section below examines the rate
26200 effects of various options depending on whether Bonneville or other entities take the lead in
26201 developing and acquiring the needed resources. It also addresses the fact that different
26202 customers are affected differently depending on these financing options and by what utility
26203 provides their power.

26204 Under the zero-carbon resource portfolio, about 1,200 MW of solar power in central Oregon
26205 and 600 MW of demand response would reduce MO1's LOLP to the No Action Alternative level.
26206 (The transmission analysis assumed solar would be located in central Oregon based on
26207 proposed projects in the interconnection queue as well as the location's high solar output.)
26208 Solar power would be more effective in reducing LOLP and lowering costs than wind energy
26209 because in MO1 the largest increases in LOLP relative to No Action Alternative occur from June
26210 through August when solar resources generate the most power. A 1,200 MW build out of solar
26211 power would require roughly 7,000 acres of land in central Oregon or approximately 11 square
26212 miles. Such a large buildout of solar capacity would likely result in additional, but currently
26213 unknown, impacts to environmental and cultural resources, which may include vegetation,
26214 wildlife habitat, archeological resources, and traditional cultural properties. Additional
26215 environmental and cultural impacts from resource replacement would be identified and
26216 analyzed by appropriate parties during future site-specific environmental review, including
26217 NEPA and permitting processes. This zero-carbon portfolio would cost \$131 million annually for

⁶² It takes a larger nameplate capacity of a new gas resource than the average generation reduction in hydropower for two reasons. The gas plant would not be able to operate at full capacity due to planning and unplanned outages for maintenance. Second, hydropower generation can be increased and decreased above the average generation level (within given operating constraints) and so is typically generating more power than the annual average during periods of high demand. Thus, to maintain reliability, an amount of new gas generation that is larger than the average hydropower generation would be necessary to provide sufficient generation during periods of high demand.

26218 the solar power and \$29 million per year for the demand response (2019 dollars).⁶³ The analysis
26219 does not include the additional generation balancing reserves needed to integrate renewable
26220 resources into the power grid.

26221 As discussed above, the LOLP impact on the No Action Alternative and MO1 from the
26222 retirement of coal plants is non-linear. Furthermore, how the coal resources are replaced (by
26223 the owners of the coal resources) affects when a utility might have more or less surplus.
26224 Specifically, if new solar resources are a large portion of the coal-plant replacements, then
26225 these utilities may have more surplus in the summer when solar power generation is most
26226 efficient. Because the seasonal pattern of generation is different in the No Action Alternative
26227 compared to MO1, the replacement resources for coal will affect the need for replacement
26228 resources for the hydropower generation loss in MO1. Because of this effect, the need for
26229 replacement resources in NAA increases more with limited coal-plant retirements and the no-
26230 coal scenario than it does for MO1. Thus, if Bonneville (or the region) acquired 1,800 MW to
26231 return MO1 to a NAA LOLP of 6.6 percent for the base case, there would be no additional needs
26232 to acquire resources in the limited-coal case or the no-coal scenario for MO1 than it would
26233 have otherwise acquired under the No Action Alternative.

26234 **BONNEVILLE FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION PLAN**
26235 **COSTS**

26236 Operational measures are similar to those analyzed under the No Action Alternative; therefore,
26237 fish and wildlife mitigation costs are estimated to be similar to those established under the No
26238 Action Alternative, and the summary rate table for the Base Case analysis includes an estimate
26239 of approximately \$339 million in annual costs for Bonneville Fish and Wildlife Program and
26240 LSRCP combined for MO1. In 2016, the Bonneville Fish and Wildlife Program spending level was
26241 \$267 million and the LSRCP spending level was \$32 million (BP-16 Rate Case). Adjusted to 2019
26242 dollars, these are \$281 million and \$34 million, respectively.

26243 **EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE**

26244 **Bonneville Interconnections**

26245 The developer of the individual replacement resources would have to develop additional
26246 transmission infrastructure, such as interconnection lines, which would result in additional
26247 costs—attributed to the cost of developing the actual resource—to reach the larger
26248 transmission network. Those costs would vary depending on the geographical location of the
26249 resource with respect to the transmission network, size of the individual project, and other
26250 factors.

26251 Bonneville, for its part of the resource interconnection, would provide additional network
26252 facilities at the interconnection substations in order to complete the interconnection of the

⁶³ See footnote 4. Replacement portfolio costs differ slightly under all applicable MOs for regional and Bonneville finances because demand response include 200 MW in the Portland area not presently served by Bonneville, and 400 MW in areas presently served by Bonneville.

26253 new resource to the larger transmission network. The Bonneville interconnection would require
26254 equipment such as bulk transformers, circuit breakers, and other substation equipment that
26255 may require the expansion of substations beyond their existing footprints. Transmission
26256 substation interconnection infrastructure like this can take several years to plan, permit, and
26257 construct, especially if the substation requires expansion beyond its current footprint.

26258 Based on the assumptions described above, Bonneville identified approximately \$70 million in
26259 direct costs on the transmission network (which customers would fund, and Bonneville would
26260 repay in transmission credits) necessary to accommodate the interconnection for the least-cost
26261 portfolio under MO1. Bonneville identified \$72 million in direct costs on the transmission
26262 network necessary to accommodate the interconnection for the zero-carbon portfolio under
26263 MO1. These costs would be between \$3.8 million and \$3.9 million when annualized.

26264 The analysis did not identify any additional Bonneville transmission infrastructure needs or
26265 transmission system reliability issues associated with the interconnections under MO1 beyond
26266 the facilities and costs described here.

26267 **Bonneville Transmission System Reliability and Operations**

26268 Changes in hydropower generation combined with replacement generation from the two
26269 replacement resource portfolios would likely not result in any transmission system reliability
26270 issues requiring transmission reliability projects beyond what has been identified in Bonneville's
26271 regular system assessments. Due to expected increases in loads in the Tri-Cities load service
26272 area, Bonneville's regular system assessments have identified several transmission reliability
26273 projects that are anticipated to occur within and beyond the 10-year planning horizon.

26274 Because MO1 provides for reduced generation capability, there would also be a reduction in
26275 the number of generating units online at a given time at the CRS projects of the lower Snake
26276 and lower Columbia Rivers. With a reduced number of operating units and uncertainty about
26277 the characteristics of replacement resources, there may be a reduced capability to provide
26278 voltage support and dynamic stability in response to significant disturbances throughout the
26279 Western Interconnection. This could result in reduced operating limits to avoid equipment
26280 damage and potential uncontrolled load loss. However, the assumed operating limits were not
26281 changed because there is not enough certainty about the possible replacement resources to
26282 have confidence that changing the limit assumptions would increase accuracy when the studies
26283 were performed.

26284 Operating at lower operating limits could result in increased congestion and result in redispatch
26285 of resources throughout the Western Interconnection to meet the required load demands at
26286 that time beyond that reported below under the Regional Transmission System Congestion
26287 Effects subsection. The effect on operating limits would vary based on the capability of
26288 resources online at the time and the location of those resources.

26289 Because coal and gas generation have similar characteristics to hydropower,⁶⁴ there may be
26290 issues with voltage and dynamic stability in scenarios with limited or zero coal and gas
26291 generation in the region. Renewable resources, such as solar generating facilities, currently
26292 have neither the technology nor the requirement to provide comparable dynamic and
26293 frequency support.

26294 Technology under development and implementation of additional requirements may be
26295 needed under a zero-carbon resource portfolio in order to have certainty that replacement
26296 solar resources will be able to provide adequate reactive and dynamic support to respond to
26297 larger transmission disturbances.⁶⁵ It could take several years to design, permit, and construct
26298 these additional transmission reinforcements should they be needed.

26299 **Regional Transmission System Congestion Effects**

26300 During high runoff conditions when more hydropower is generated, the number of congestion
26301 hours in the west-to-east flow direction would be greatest along the Hemingway-Summer Lake
26302 transmission path, which would experience higher congestion hours (up to 214 additional
26303 hours) compared to No Action. Other west-to-east flow paths would experience modest (less
26304 than 50 hours) shifts in the number of hours of congestion. During times of transmission path
26305 congestion, the transmission of power generated in the west would be limited and loads would
26306 need to be served by higher cost generating resources east of the congested path, which would
26307 result in higher costs to serve the load during those times.

26308 With the exception of the Pacific DC Intertie, the north-to-south paths would have modest
26309 changes in congestion hours. The congestion on the Pacific DC Intertie in the north-to-south
26310 flow direction would increase up to 71 hours, depending on hydro runoff conditions and the
26311 replacement resource portfolio. If the assumed replacement resources were not in place when
26312 the changes in hydropower generation were implemented under this alternative, the number
26313 of hours and location of congestion would change depending on which replacement resources
26314 were online.

26315 Under limited or no-coal scenarios, the congestion effects of CRS hydropower reductions with
26316 or without replacement resources could be amplified above what is reported above.

26317 Detailed graphs depicting the number of hours of congestion along the individual paths under
26318 different water years appear in Appendix H.

⁶⁴ Hydro, coal, gas, and nuclear generation all provide rotating inertia and voltage control capability that contribute to the stability of the transmission system.

⁶⁵ Examples of requirements could include: increased synchronous condensing capability (i.e., a free-spinning motor that adjusts to conditions on the power grid to provide voltage support) at the lower Columbia River projects; Addition of static reactive power devices (electrical devices that provide quick response to maintain voltage stability) at strategic points on the transmission system (voltage support only); An increased requirement for generating units at the lower Columbia River projects to be online in order to provide voltage and dynamic support for requirements of the transmission system.

26319 Overall, changes in the patterns of CRS generation under MO1 and its replacement resource
26320 portfolios would have a relatively small or minor impact on congestion for Pacific Northwest
26321 transmission paths.

26322 **ELECTRICITY RATE PRESSURE**

26323 **Bonneville Wholesale Power Rates**

26324 Under MO1, assuming that the region acquires the necessary replacement resources,
26325 Bonneville's wholesale power rate would experience upward rate pressure for all portfolios in
26326 MO1 relative to the No Action Alternative, with the greatest upward rate pressure related to the
26327 zero-carbon portfolio. Bonneville or other entities not be able to offset the additional costs
26328 identified in MO1 the upward rate pressure would lead to rate increases. Average Bonneville
26329 Wholesale Power Rate under Multiple Objective 1. Line 1 presents the estimated wholesale
26330 power rate based on changes in the amount of hydropower generated and the surplus (market)
26331 sales for the base case without additional coal plant retirements. These rate estimates also
26332 include annualized structural cost measures, which total \$20.7 million (2019 dollars) under MO1.
26333 Appendix H, *Power and Transmission*, presents detailed information on structural measure costs
26334 and the effects on wholesale power rates.

26335 On average, upward rate pressure may result in increases in Bonneville's wholesale power rates
26336 of \$2.08 per MWh to \$2.97 per MWh depending on the replacement portfolio and financing
26337 portfolio (2019 dollars). This would represent a 6.0 to 8.6 percent increase in the average
26338 Bonneville wholesale power rate compared to the No Action Alternative.

26339 Summary results for Bonneville's wholesale power rate pressure analysis in the Bonneville
26340 Finances scenario are presented in the first section of Table 3-133. As discussed in Section
26341 3.7.3.1, the second section of Table 3-133 provides the cost pressure to the region of MO1 in
26342 light of potential carbon compliance and accelerated coal retirements. Results for the Region
26343 Finances scenario are presented following this discussion. The summary analysis focuses on the
26344 Bonneville Finances scenario because this includes most of the relevant costs affecting
26345 Bonneville's customer base, while the Region Finances scenario excludes real costs affecting
26346 regional rates that are not explicitly included in Bonneville's wholesale rate.

26347 **Bonneville Finances**

26348 **Table 3-133. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 1,**
26349 **for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures**
26350 **Associated with Additional Sensitivity Analysis**

Change in Bonneville's Priority Firm Rate, Bonneville Finances					
		Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
		\$ rate pressure	change from NAA	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)					
1	Base Rate	\$37.53 /MWh	\$2.97 /MWh	\$36.64 /MWh	\$2.08 /MWh
2	Change from NAA due to Costs	\$172	8.4%	\$80	4.0%
3	Change from NAA due to Load		0.2%		2.0%
4	Total Base Change in Rate		8.6%		6.0%
Rate Sensitivities (annual cost in \$ millions)					
5	Fish and Wildlife Costs				
6	Integration Services	\$29 to \$34	1.3% to 1.5%		
7	Resource Financing Assumptions	\$0 to \$30	0% to 1.4%	\$0 to \$6	0% to 0.3%
8	Resource Cost Uncertainties	\$0 to \$6	0% to 0.3%	\$0 to \$3	0% to 0.1%
9	Demand Response	-\$12 to \$52	-0.5% to 2.4%		
10	Oversupply	\$3 to \$4	0.1% to 0.2%	\$1 to \$1	0% to 0%
11	Total Rate Sensitivities	\$20 to \$126	0.9% to 5.8%	\$1 to \$10	0.0% to 0.4%
12	Total Base Effect + Sensitivities	\$192 to \$298	9.5% to 14.4%	\$81 to \$90	6.0% to 6.4%
Other Regional Cost Pressure (annual cost in \$ millions)					
		Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
		\$ pressure	change from NAA	\$ pressure	change from NAA
13	Regional Cost of Carbon Compliance	-\$16 to \$88		\$11 to \$57	
14	Regional Coal Retirements (capital)	\$0 to \$0			
15	Regional Coal Retirements (other)	too uncertain to estimate		too uncertain to estimate	

26351 Note: Line 14 represents the approximate range in fixed costs for replacement resources for the more limited coal
26352 scenario and the no coal scenario. Additional changes in value, denoted by line 15, would occur from changes in
26353 market prices, changes in technology, and many other factors. Because the retirement of coal plants in the region
26354 will change the utility landscape far from the current condition, there is not enough information available to
26355 extrapolate from today's information. Base rate includes Colville Settlement Payment, which has a 0 to 1 percent
26356 increase from No Action Alternative.
26357

26358 **Base Case Analysis**

26359 In the Bonneville Finance Scenario, base rate pressures range from 6.0 percent to 8.6 percent
26360 depending on the resource portfolio, with a higher rate pressure associated with the zero-
26361 carbon resource replacement. In the zero-carbon scenario, annual average cost pressure from
26362 changes due to costs is \$172 million per year (2019 dollars) which equates to a 8.4% upward
26363 pressure on rates, coupled with a small increase in preference customer loads resulting in a
26364 0.2% upward pressure on power rates, resulting in an overall change to base rates of 8.6%. Rate

26365 pressure includes a reduction in net secondary revenues, increased capital costs to finance and
26366 maintain the solar resource replacement, structural measure debt financing, and higher energy
26367 efficiency expenses associated with the demand response program. In the conventional least-
26368 cost scenario, the \$80 million per year (2019 dollars) in upward rate pressure which equates to
26369 a 4.0% upward rate pressures, is associated with lower net secondary revenues, and capital,
26370 fuel and O&M costs associated with the gas turbine resource replacement, as well as structural
26371 measure debt financing. In addition to these cost pressures, loads in the conventional least-cost
26372 scenario are lower, contributing alone to a 2.0 percent upward pressure on power rates.
26373 Overall, the base rate pressure is 6.0%.

26374 Rate Sensitivity Analysis

26375 Rate sensitivities are presented in Table 3-133, lines 5 through 11, to provide quantitative
26376 estimates relative to additional sensitivity analyses described in Section 3.7.3.1. No sensitivity is
26377 provided for the Bonneville Fish and Wildlife programmatic expenses (line 5) because the cost
26378 analysis identified equivalent spending with the No Action Alternative.

26379 For Integration Services (line 6), other than energy shaping effects between heavy load hours⁶⁶
26380 (HLH) and light load hours⁶⁷ (LLH) periods, changes in the value of lost flexibility due to
26381 increased spill and other constraints on the CRS under MO1 are not explicitly included in base
26382 rates. Generation inputs revenues for contingency reserves and balancing services are assumed
26383 to be the same as the No Action Alternative. However, the ability of the CRS to carry generation
26384 balancing reserves is reduced under MO1. To monetize the value of changes in contingency and
26385 generation balancing reserve carrying capability, the sensitivity analysis incorporates
26386 integration costs associated with contingency and balancing needs of replacement resources.

26387 Annual resource integration costs associated with replacement resources under MO1 were
26388 calculated using BP-20 operating and generation balancing reserve rates. Estimated annual
26389 integration costs for the 1200 MW solar resource replacement under MO1 for the zero carbon
26390 portfolio ranged from \$29 million to \$34 million.

26391 Resource replacement financing (line 7), which addresses alternative amortization periods to
26392 the 30 years assumed in base rates, shows upward cost pressure of \$30 million per year in the
26393 zero-carbon portfolio and \$6 million per year in the conventional least-cost scenario. Resource
26394 cost uncertainties (line 8) range from a \$6 million per year upward rate cost pressure to a \$6
26395 million per year downward rate cost pressure in the zero-carbon scenario, and \$3 million per
26396 year in the conventional least-cost scenario. Demand response costs (line 9) could be lower
26397 than assumed in the \$20 million/year in base rates; a potential cost savings of 12 million per
26398 year is shown on the low end for this sensitivity. However, to account for the challenges to
26399 scaling up demand response programs in Bonneville's service territory, this portion of the

⁶⁶ Heavy load hours are Monday through Saturday hour ending 7 through 22 (i.e. 6 am to 10 pm), excluding NERC holidays.

⁶⁷ Light load hours are Monday through Saturday hour ending 23 through 6 (i.e. 10 pm to 6 am), including NERC holidays, and all day on Sundays.

26400 resource portfolio could be as high as \$52 million per year higher than assumed in base rates if
26401 up to 50 percent of the program needed to be replaced with a 300 MW solar resources with
26402 battery technology instead. OMP costs associated with oversupply events could be \$3 to \$4
26403 million per year higher in the zero-carbon scenario, and \$1 million higher in the conventional
26404 least-cost scenario.

26405 Other Regional Cost Pressure

26406 Line 13 provides an estimate of the incremental carbon compliance costs associated with MO1.
26407 Effects associated with regional carbon compliance laws are unknown, pending current
26408 legislation in Oregon and Washington as discussed in Section 3.7.3.1. If binding estimates
26409 effective in the future are enforced to the resource portfolio in MO1, regional utilities could
26410 face cost savings relative to the No Action Alternative of as much as \$16 million per year, or
26411 cost pressures as much as \$88 million per year in the zero-carbon scenario. In the conventional
26412 least-cost scenario, carbon enforcement costs could range between \$11 million and \$57 million
26413 per year.

26414 As described in Sections 3.8.3.1, Availability of Coal Resources subsection, and 3.8.3.2, Effects
26415 on Power System Reliability subsection, regional utilities would need to add 8,800 MW of
26416 additional zero-carbon resources in the limited coal capacity scenario and 28,000 MW of
26417 additional zero-carbon resources in the no coal capacity scenario to maintain regional LOLP at
26418 No Action Alternative levels (6.6 percent). See Table 3-133. Lines 14 and 15 estimate the
26419 incremental zero-carbon resources costs needed by the region to maintain the No Action
26420 Alternative LOLP of at least 6.6 percent under MO1 in light of a limited or no coal assumption.
26421 An “incremental zero-carbon resource cost” occurs if the combination of (1) the resources
26422 Bonneville or the region is expected to acquire under MO1, plus (2) 8,800 MW (under the
26423 limited coal scenario) or 28,000 MW (under the no coal scenario), is less than the total amount
26424 of zero-carbon resources needed to return the region to the No Action Alternative LOLP of 6.6
26425 percent under the applicable coal scenario.

26426 For the limited coal capacity scenario under MO1, a minimum of 9,300 MW of zero-carbon
26427 resources would need to be added to maintain regional LOLP at the No Action Alternative level
26428 of 6.6 percent. See Table 3-132. Bonneville or the region is expected to acquire 1,800 MW of
26429 zero-carbon resources under MO1 in the base case analysis. Adding 1,800 MW to 8,800 MW
26430 exceeds the minimum 9,300 MW, so this MO has no incremental cost impact on the region if a
26431 limited coal scenario is assumed.

26432 For the no coal capacity scenario under MO1, a minimum of 27,000 MW of zero-carbon
26433 resources would be needed to maintain regional LOLP at the No Action Alternative level of
26434 6.6 percent. See Table 3-132. Because this number is already below 28,000 MW (the amount of
26435 zero-carbon resources needed under the No Action Alternative in the no coal scenario), this MO
26436 has no incremental cost impact on the region if a no coal scenario is assumed.

26437 **Region Finances**

26438 Results for the region finances scenario are presented in Table 3-134. It is important to note the
 26439 rate pressures in this table are from the perspective of Bonneville’s wholesale power rates.
 26440 In the region finances scenario, replacement resource costs are excluded from Bonneville’s
 26441 wholesale rate, with those costs collected from rates charged by other entities in the region,
 26442 ultimately paid by the customers of utilities that would be receiving less power from Bonneville.
 26443 The Socioeconomic section below shows the geographic distribution of rate pressure down to
 26444 retail rates in both scenarios, so that the costs that are not in Bonneville rates in the region
 26445 finances scenario are included in retail rate impacts of the consortium of public customers
 26446 assumed to finance the resource replacement.

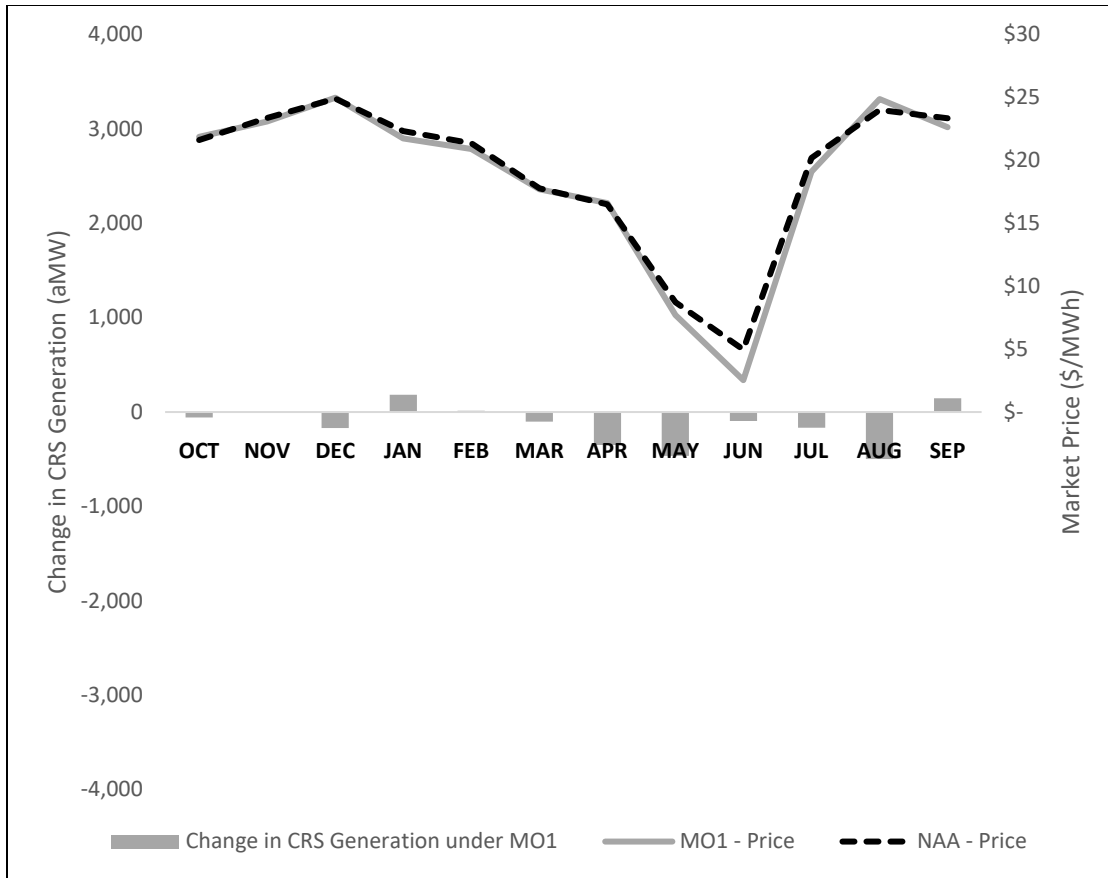
26447 **Table 3-134. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 1,**
 26448 **for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures**
 26449 **Associated with Additional Sensitivity Analysis for the Case, Region Finances**

Change in Bonneville's Priority Firm Tier 1 Rate, Region Finances				
	Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
	\$ rate pressure	change from NAA	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)				
Base Rate	\$36.83 /MWh	\$2.27 /MWh	\$36.14 /MWh	\$1.57 /MWh
Change from NAA due to Costs	\$78	3.9%	\$38	1.9%
Change from NAA due to Load		2.7%		2.7%
Total Base Change in Rate		6.6%		4.5%

26450

26451 **Market Prices**

26452 The surplus market sales vary depending on the replacement resource while the amount of
 26453 surplus power would increase for all portfolios. In order to meet power system reliability needs
 26454 at all times, enough solar had to be added to meet periods of highest demand, the peaks in the
 26455 winter, leading to periods of surplus at other times, such as in the summer. The average market
 26456 price also experiences upward price pressure, potentially leading to increases in price to
 26457 \$19.63 per MWh under the conventional least-cost portfolio, and downward price pressure,
 26458 potentially leading to decreases in price to \$19.18 per MWh under the zero-carbon portfolio.
 26459 These effects would be changes of +1.1 percent and -1.2 percent relative to the No Action
 26460 Alternative price of \$19.42 per MWh. Figure 3-179 shows the average market price and average
 26461 CRS hydropower generation by month under the least-cost portfolio. Relative to the No Action
 26462 Alternative, average prices decline by \$1.0 per MWh in September when generation is relatively
 26463 high.



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Figure 3-179. Monthly CRS Generation (aMW) and Market Price (\$/MWh).

Note: The right axis is the market price (\$/MWh). The left axis is generation from the CRS projects by month (aMW).

Source: Power Analysis.

26469 **Bonneville Wholesale Transmission Rate Pressure**

26470 Under MO1, the Bonneville wholesale transmission rate pressure would increase for both
 26471 portfolios relative to the No Action Alternative, with the highest increases related to the least-
 26472 cost replacement portfolio. The upward transmission rate pressure would be 0.74 percent
 26473 annualized (6.1 percent over an 8-year period) under the least-cost replacement portfolio and
 26474 0.62 percent annualized (5.1 percent over an 8-year period) under the zero-carbon replacement
 26475 portfolio. Changes in capital costs, and long- and short-term sales, contribute to this upward
 26476 rate pressure. Although the capital costs associated with interconnecting the zero-carbon
 26477 replacement portfolio would be greater than the least-cost portfolio under MO1, the potential
 26478 for additional long-term sales associated with the amount of solar power generation under the
 26479 zero-carbon portfolio would likely result in lower overall transmission rate pressure. The short-
 26480 term sales associated with the zero-carbon replacement portfolio would also increase,
 26481 reflecting the changes to hydropower generation and associated market pricing (see described
 26482 above). Across customers and portfolios, the range of annualized increases is 0.28 to
 26483 1.55 percent.

26484 **Retail Rate Effects**

26485 The retail rate that end users pay to their individual utilities for electricity would experience
26486 slight upward rate pressure under MO1 compared to the No Action Alternative. Should the
26487 upward rate pressure lead to increases in rates, the average retail rates under MO1 could range
26488 from 10.27 cents per kWh to 10.28 cents per kWh depending the replacement resource
26489 portfolio for residential end users. Retail rate pressures differ depending on how replacement
26490 resources are financed and whether the retail customer is receiving power from a utility
26491 supplied by Bonneville or whether the utility has different sources of generation. The rate
26492 pressures across portfolios would also be similar for commercial and industrial end users. These
26493 retail rates are 0.74 percent higher for the zero-carbon portfolio and 0.62 percent higher for the
26494 least-cost portfolio relative to the No Action Alternative.

26495 **BONNEVILLE FINANCIAL ANALYSIS**

26496 As previously described, the Bonneville financial analysis considers the effects of the MOs on
26497 future cash flows over a 30-year financing period for potential replacement resources.
26498 For MO1, the discounted NPV of the cash flow effects under each resource replacement
26499 portfolio are described in Table 3-135 below. This NPV analysis is Bonneville specific and does
26500 not capture wider societal impacts. This NPV analysis uses a risk adjusted discount rate of
26501 7.9 percent and a 30-year timeframe. The sensitivities in this analysis are described in the
26502 Power Rates Table 3-133.

26503 **Table 3-135. Bonneville Financial Analysis Results (in Millions \$2019)**

Analysis Type	MO1	
	Zero Carbon	Conventional Least-Cost
Power	-\$2,184	-\$1,516
Transmission	-\$101	-\$106
Total Base Impact – Bonneville	-\$2,285	-\$1,622

26504 **SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION**

26505 Except where noted, this section describes the base analysis for MO1 without considering the
26506 range of additional costs shown in Table 3-133, and without the retirement of additional coal-
26507 plants.

26508 **Social Welfare Effects**

26509 This social welfare analysis employs both the market price and production cost methods based
26510 on the base case for this analysis, assuming no additional coal plant retirements. As described
26511 in further detail in Section 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*, the
26512 market price method estimates the societal loss or gain from changes in hydropower
26513 generation, valued at the monthly market price while the production cost method estimates
26514 the fixed and variable costs, both power resources and transmission, associated with providing

26515 power. These two approaches are not additive and present a national perspective without
 26516 considering specific populations or regions, as discussed in the *Regional Economic Effects*
 26517 section, below.

26518 Table 3-136 presents the market value of the reduction in Pacific Northwest hydropower
 26519 generation under MO1 as compared with the No Action Alternative. Based on the market price
 26520 method, the average annual economic effect of MO1 is a \$25 million cost. As previously
 26521 described, there is considerable uncertainty regarding how the social welfare effects may
 26522 change over the 50-year timeframe of the analysis. For example, regulatory and policy changes,
 26523 technology, and the cost of technology change over time, influencing this value. However, if the
 26524 average annual effects of \$25 million persist over a 50-year timeframe (2022-2071), the net
 26525 present value would be \$680 million.⁶⁸

26526 **Table 3-136. Average Annual Social Welfare Effect of Multiple Objective 1 Based on the**
 26527 **Market Price of Changes in Pacific Northwest Hydropower Generation (2019 U.S. Dollars)**

Portfolio	Change in Generation (aMW)	Change in Generation (MWh)	Average Annual Social Welfare Effect
MO1	-170	-1,500,000	-\$25,000,000

26528 Note: Changes in hydropower generation and the social welfare value are rounded to two significant digits.
 26529 The weighted average market price is calculated based on average generation and prices across 14 time periods
 26530 over the course of a year. Additional detail on this analysis is provided in Chapter 5 of Appendix H.

26531 Table 3-137 evaluates the social welfare effects of MO1 based on the additional costs of adding
 26532 enough capacity to the system to meet power demand given the reduction in hydropower
 26533 generation described in Table 3-131, Monthly Electricity Generation at the Columbia River
 26534 System Projects under Multiple Objective 1. That is, the social welfare effects quantified based
 26535 on the production cost method are the marginal costs of providing power to maintain power
 26536 system reliability. Based on this approach, the social welfare effects of MO1 range from an
 26537 average annual cost of \$64 million (assuming a least-cost replacement resource portfolio) to
 26538 \$170 million (assuming a zero-carbon replacement resource portfolio). Under the zero-carbon
 26539 replacement resource portfolio, MO1 results in a net reduction in variable costs. This is because
 26540 the variable costs account for changes in the cost of fuel for fossil fuel power plants, which is
 26541 reduced relative to the No Action Alternative assuming the zero-carbon replacement resource
 26542 portfolio. Even under the zero-carbon replacement resource portfolio, MO1 results in a net
 26543 increase in variable costs. This is because the variable costs account for changes in the cost of
 26544 fuel and other variable costs for fossil fuel power plants across the Western Interconnection,
 26545 which increases relative to the No Action Alternative assuming the zero-carbon replacement
 26546 resource portfolio. If these social welfare effects persist over a 50-year timeframe, the present
 26547 value effects would be \$1.7 billion to \$4.6 billion.

⁶⁸ The present values of social welfare effects in this analysis are expressed in 2019 dollars and assume a 2.875 discount rate, which is the 2019 Federal water resources planning discount rate.

26548 **Table 3-137. Average Annual Social Welfare Effect of Multiple Objective 1 Based on the**
26549 **Increased Cost of Producing Power to Meet Demand (2019 U.S. Dollars)**

Production Cost Factor ^{1/}	Replacement Resource Portfolio	
	Zero Carbon	Conventional Least Cost
Annualized Fixed Cost of Replacement Resources	-\$160,000,000	-\$27,000,000
Annualized Fixed Cost of Transmission Infrastructure	-\$3,900,000	-\$3,800,000
Average Annual Variable Costs	-\$2,500,000	-\$33,000,000
Average Annual Social Welfare Effects	-\$170,000,000	-\$64,000,000

26550 Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
26551 1/ Negative values in the table represent an increase (net cost) in the cost of producing power.

26552 **Regional Economic Effects**

26553 Estimated average retail electricity rates would experience upward rate pressure under MO1 by
26554 roughly a tenth of a cent per kWh for the zero-carbon portfolio and slightly less under the least-
26555 cost portfolio relative to the No Action Alternative. These upward retail rate pressures may
26556 increase average electricity expenditures by 0.62 to 0.74 percent, depending on the portfolio,
26557 for electricity consumers across the region relative to the No Action Alternative.

26558 **Residential Effects**

26559 Examining potential upward retail rate pressure on a geographic basis, the effects of MO1
26560 would affect residential end users across the Pacific Northwest. The majority of households in
26561 the region (between 73 and 85 percent) would experience an upward rate pressure of 0 to
26562 1 percent under the least-cost resource portfolio. One percent of households would experience
26563 upward rate pressure of greater than 5 percent under the zero-carbon portfolio and one
26564 quarter of regional households would experience downward rate pressure. The downward rate
26565 pressure is primarily due to reduced market prices and variable costs compared to the No
26566 Action Alternative. Households served by utilities receiving power from Bonneville would
26567 experience larger increases in rate pressure than households served by utilities not receiving
26568 power from Bonneville.

26569 While rates remain highest in rural areas, the upward retail rate pressure would occur across
26570 the entire region. Large metropolitan urban areas would experience the smallest upward rate
26571 pressure relative to the No Action Alternative. Urban areas that are not adjacent to metro areas
26572 would experience the largest upward rate pressure, ranging from 0.60 to 1.4 percent. By CRSO
26573 region, rate effects would be concentrated in Region D with average increases in rate pressure
26574 ranging from 1.0 to 1.7 percent. Region A would also experience relatively high average
26575 increases in rate pressure ranging from 0.64 to 1.1 percent. Table 3-138 summarizes the rate
26576 effects by CRSO region.

26577 **Table 3-138. Average Residential Rate Pressure Effects by Region with Percentage Change of**
26578 **Multiple Objective 1 Compared to the No Action Alternative**

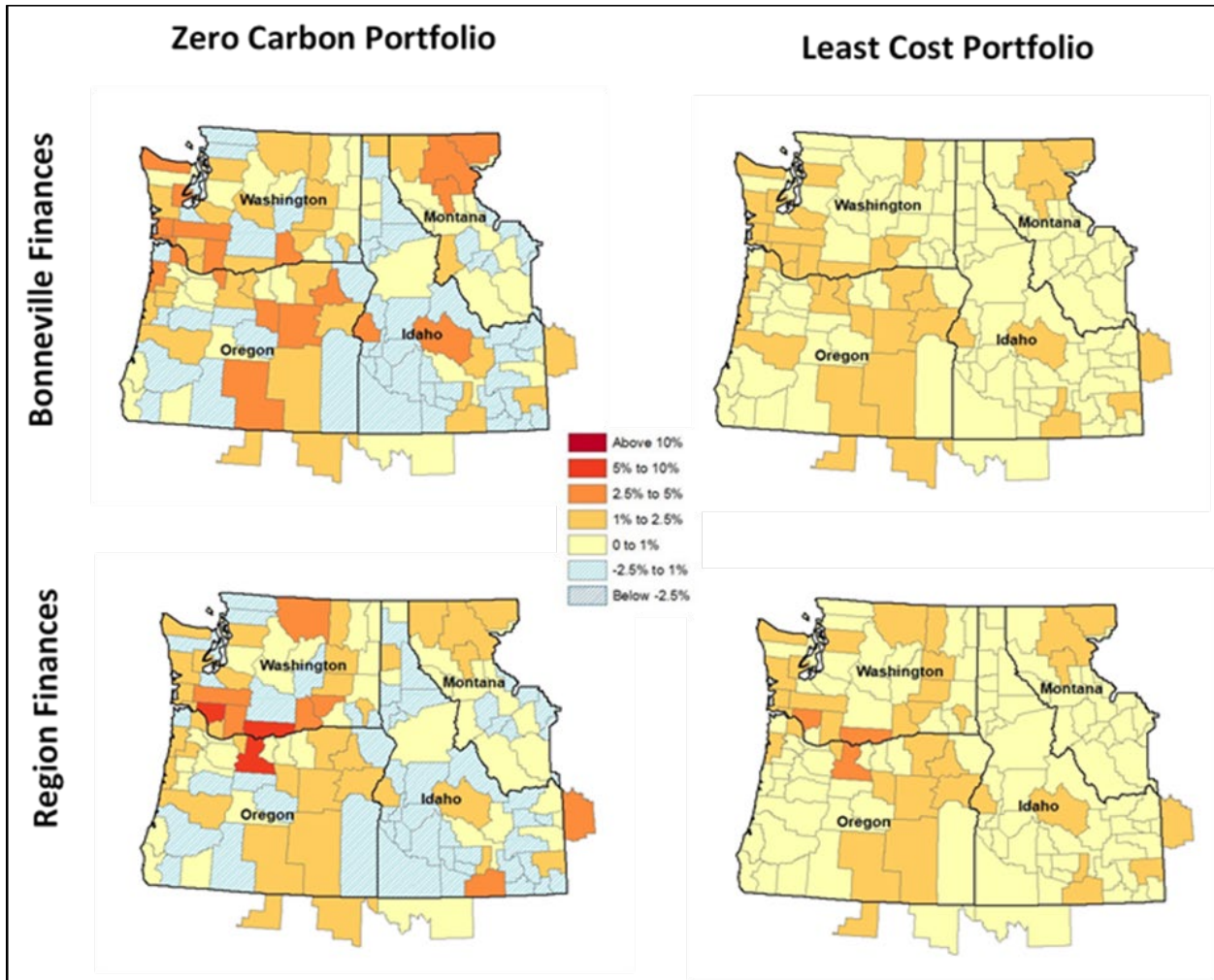
CRSO Region	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Region A	1.1%	0.81%	0.86%	0.64%
Region B	0.63%	0.60%	1.2%	0.75%
Region C	0.36%	0.44%	0.31%	0.39%
Region D	1.2%	1.01%	1.7%	1.05%
Other	0.66%	0.69%	0.58%	0.56%

26579 Figure 3-180 maps potential residential retail rate pressure effects by county for MO1.
26580 In general, upward rate pressure could be 0.62 to 0.74 percent, with only 1 percent of
26581 households experiencing rate pressure over 5 percent (under the zero-carbon Region-financed
26582 portfolio). Under the Bonneville-financed portfolio with a zero-carbon portfolio, 24 counties
26583 across the region would experience upward rate pressure greater than 2.5 percent relative to
26584 the No Action Alternative. These counties are largely non-metropolitan areas that represent
26585 5.6 percent of households in the Pacific Northwest region.

26586 Over time, upward rate pressure would increase faster under MO1 relative to the No Action
26587 Alternative (Table 3-139). This is due to the rate pressure that increases retail rates slightly over
26588 the period of analysis. By 2041, the difference in residential retail rates would increase from
26589 0.67 in 2022 to 1.2.

26590 To the extent that the upward rate pressure leads to changes in rates, end users would increase
26591 spending on electricity. The average increase in expenditures under MO1 relative to the No
26592 Action Alternative would range from 0.53 to 0.74 percent, depending on the portfolio. By 2041
26593 the difference in rates grows under the different portfolios due to the increasing rate pressures.
26594 In 2041, the average increase in monthly bills ranges from \$0.50 to \$0.80 per month relative to
26595 the No Action Alternative. Table 3-140 presents the portion of regional households that
26596 experience a range of changes in expenditures.

26597 Residential consumers in some counties would experience changes ranging from small
26598 reductions to up to \$64 increases in their annual electricity spending compared to No Action in
26599 2022. In the Bonneville-financed scenario, the average increase in annual electricity spending is
26600 \$7 per year for both the zero-carbon and least-cost resource portfolios. As a percentage of
26601 income in counties, the average effects of MO1 relative to No Action are minimal with changes
26602 of 0.01 percent of annual income on average. The average percent of median income spending
26603 on power would increase from 1.69 percent under the No Action Alternative to 1.7 percent
26604 under MO1. The largest increase would be a 0.1 percent increase in the percentage of income
26605 spent on electricity. The total increase in household spending on electricity across all Pacific
26606 Northwest households is between \$35 million and \$41 million per year depending on the
26607 replacement resource portfolio.



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Figure 3-180. Residential Electricity Rate Pressure Effects of Multiple Objective 1 by Portfolio

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Table 3-139. Average Upward Retail Rate Pressure Effect under Multiple Objective 1 in 2022 and 2041, Relative to the No Action Alternative

Financing	Portfolio	Residential		Commercial		Industrial	
		2022	2041	2022	2041	2022	2041
Bonneville	Zero-Carbon	0.71%	1.3%	0.75%	1.3%	1.0%	1.6%
	Conventional Least-Cost	0.70%	1.4%	0.74%	1.4%	0.98%	1.7%
Region	Zero-Carbon	0.74%	1.3%	0.77%	1.3%	1.0%	1.8%
	Conventional Least-Cost	0.62%	1.3%	0.66%	1.3%	0.86%	1.5%

26612 **Table 3-140. Percentage of Residential End Users Who Experience Changes in Electricity**
26613 **Expenditures by Size of Expenditure Change in each Portfolio under Multiple Objective 1**

Sector	Expenditures Change	Bonneville Finances		Region Finances	
		Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Residential	>+10%	0%	0%	0%	0%
	+5 to 10%	0%	0%	1.2%	0%
	+2.5 to 5%	5.6%	0%	3.1%	0%
	+2.5% to 1%	24%	27%	25%	15%
	+0% to 1%	45%	73%	46%	85%
	Decrease	25%	0%	25%	0%

26614 Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

26615 The EIA estimates short- and long-term electricity elasticities for one, two, and three years out
26616 from price changes, as well as the long term at year 25. Appendix H presents these elasticity
26617 estimates (EIA 2015). Given the small upward rate pressure under MO1, the effect on
26618 residential demand would be less than 1 percent under MO1 in many counties. Some counties
26619 that experience slight downward rate pressure (benefits) and could increase consumption of
26620 electricity. Counties with the highest upward rate pressure could adjust consumption and save
26621 up to \$7.7 per year.

26622 This analysis considers how the region wide changes in household spending on electricity would
26623 affect demand for other goods and services across the region. That is, increased spending on
26624 electricity may reduce spending on other items, affecting regional economic productivity. This
26625 analysis applies IMPLAN to model the increased spending on electricity as a reduction in
26626 household income (direct effect) and quantifies the multiplier effects on interrelated economic
26627 sectors (indirect and induced effects). This analysis finds that the potential increased cost of
26628 household electricity could result in the loss of between \$37 million and \$43 million in regional
26629 output (sales) and between 240 and 270 jobs (Table 3-141). The majority of regional economic
26630 effects would occur Washington and Oregon.

26631 **Table 3-141. Regional Economic Effects from Changes in Household Spending on Electricity**
26632 **under Multiple Objective 1 by Portfolio**

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Output	-\$42 million	-\$42 million	-\$43 million	-\$37 million
Value Added	-\$25 million	-\$25 million	-\$26 million	-\$22 million
Labor Income	-\$14 million	-\$14 million	-\$14 million	-\$12 million
Employment	-270 jobs	-270 jobs	-270 jobs	-240 jobs

26633 Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional
26634 economy.

26635 **Commercial and Industrial Effects**

26636 Commercial and industrial rates under MO1 would also experience upward rate pressure
26637 compared to the No Action Alternative. Counties with the largest percentage of businesses in
26638 the region (King, Pierce, Snohomish and Multnomah Counties) would experience upward rate
26639 pressure under MO1 ranging from 0.3 to 2.6 percent relative to the No Action Alternative
26640 depending on the portfolio. Some counties would experience downward rate pressure;
26641 however, these are predominantly counties that do not have a large number of commercial end
26642 users. Table 3-142 presents the fraction of commercial and industrial end users that would
26643 experience upward rate pressure potentially leading to increases in expenditures on electricity
26644 above certain thresholds under MO1 compared to the No Action Alternative.

26645 Relative to the No Action Alternative, expenditures on electricity would increase for both
26646 commercial and industrial end users. The average increases for commercial end users would
26647 range from \$3.3 per month up to \$3.8 per month depending on the replacement resource
26648 portfolio and financing portfolio. Over time, these increases would widen with continued rate
26649 pressure and the uncertainty of retail rate growths. Industrial end users would spend, on
26650 average, \$40 to \$47 more per month under MO1 relative to No Action. Many of the increases in
26651 the industrial rate would occur in counties without large numbers of industrial businesses
26652 (e.g., less than 0.2 percent of all regional industrial customers).

26653 **Table 3-142. Percentage of Commercial and Industrial End Users Who Experience Changes in**
26654 **Electricity Expenditures by Size of Expenditure Change under Multiple Objective 1**

Sector	Expenditure Change	Bonneville Finances		Region Finances	
		Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Commercial	>+10%	0%	0%	0%	0%
	+5 to 10%	0%	0%	1.6%	0%
	+2.5 to 5 %	11%	1.1%	5.0%	1.0%
	+2.5% to 1%	15%	24%	20%	17%
	+0% to 1%	48%	75%	48%	82%
	Decrease	26%	0%	25%	0%
Industrial	>+10%	0%	0%	0.52%	0%
	+5 to 10%	1.1%	0%	3.4%	0%
	+2.5 to 5 %	13%	10%	12%	4.5%
	+2.5% to 1%	16%	21%	13%	25%
	+0% to 1%	42%	69%	42%	71%
	Decrease	27%	0%	28%	0%

26655 Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

26656 Under MO1, the total upward rate pressure across commercial businesses in the Pacific
26657 Northwest would be between \$11 million and \$13 million per year. This analysis uses the
26658 IMPLAN model to quantify the multiplier effects of the change in commercial sector
26659 productivity (Table 3-143). The multiplier effects reflect how the increased costs of doing

26660 business may affect demand for inputs to production across commercial businesses. This
26661 analysis finds that the increased cost of electricity to regional commercial businesses would
26662 result in the loss of between \$18 million and \$21 million in regional output (sales) and between
26663 120 to 140 jobs depending on the replacement scenario. The majority of regional economic
26664 effects would occur Washington and Oregon.

26665 **Table 3-143. Regional Economic Effects from Changes in Commercial Business Spending on**
26666 **Electricity under Multiple Objective 1**

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Output	-\$21 million	-\$21 million	-\$21 million	-\$18 million
Value Added	-\$13 million	-\$13 million	-\$13 million	-\$12 million
Labor Income	-\$6.7 million	-\$6.8 million	-\$6.8 million	-\$5.9 million
Employment	-140 jobs	-140 jobs	-140 jobs	-120 jobs

26667 Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional
26668 economy

26669 Under MO1, the total increase in spending on electricity across industrial businesses in the
26670 Pacific Northwest would be between \$40 million and \$46 million per year. Similar to the
26671 commercial spending analysis, the IMPLAN model is used to quantify the multiplier effects of
26672 the change in industrial sector productivity (Table 3-144). This analysis finds that the increased
26673 cost pressure to regional industrial businesses would result in the loss of between \$65 million
26674 to \$76 million in regional output (sales) and between 420 to 490 jobs. Again, the majority of
26675 regional economic effects would occur Washington and Oregon.

26676 **Table 3-144. Regional Economic Effects from Changes in Industrial Business Spending on**
26677 **Electricity under Multiple Objective 1**

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Output	-\$75 million	-\$76 million	-\$74 million	-\$65 million
Value Added	-\$47 million	-\$48 million	-\$47 million	-\$41 million
Labor Income	-\$24 million	-\$24 million	-\$24 million	-\$21 million
Employment	-490 jobs	-490 jobs	-480 jobs	-420 jobs

26678 Note: 1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional
26679 economy

26680 The effects on commercial and industrial businesses described above is predicated on the
26681 region acquiring replacement resources for the reduction in hydropower generation. If the
26682 replacement resources are not developed, there would be an increased risk to power system
26683 reliability. Power shortages might occur in about 1 in 9 years. These power shortages

26684 (blackouts) would have adverse effects on the region as a whole, including commercial and
26685 industrial end users.

26686 **Other Social Effects**

26687 Under MO1, expenditures on residential electricity would remain within historical bounds and
26688 are unlikely to create negative health and safety concerns related to energy insecurity. This is
26689 because rates would remain relatively low, especially relative to income growth and slow load
26690 growth (American Council for an Energy-Efficient Economy 2017; EIA 2018a). Under MO1, no
26691 power system reliability effects would occur if replacement resources return LOLP to the No
26692 Action level so the potential for additional safety concerns related to power outages is unlikely
26693 to differ relative to the No Action Alternative. However, if the region (Bonneville or other
26694 regional entities) does not acquire additional resources, there would be an increased risk of
26695 power shortages and blackouts, which could lead to additional safety concerns. The risk of
26696 having a year with significant power shortages would nearly double. Because it can take many
26697 years to plan, site, permit, and construct new resources, the region might face this increased
26698 reliability risk after hydropower generation is reduced in MO1 until the new resources are
26699 available.

26700 **SUMMARY OF EFFECTS**

26701 Hydropower generation from the CRS projects would decrease by 130 aMW (roughly the
26702 amount of power consumed by 100,000 Northwest homes, or a city about the same size as
26703 Everett, Washington in a year) relative to the No Action Alternative on average under historical
26704 water conditions. The FCRPS would lose 290 aMW of firm power available for long-term, firm
26705 power sales to preference customers under critical water conditions. MO1 increases the LOLP
26706 to 11 percent due to the loss of hydropower, primarily in August, and would require
26707 replacement resources to return the region to the No Action Alternative LOLP of 6.6 percent.
26708 To replace the lost hydropower for power system reliability, the replacement resources not
26709 only need to replace the average energy but also replace some of the peaking ability of the
26710 hydropower system. Therefore, the amount of replacement resources (e.g., 560 MW gas)
26711 exceed the amount of average power lost (-130 aMW). These replacement resources would
26712 increase the wholesale transmission rate pressure and wholesale power costs for regional
26713 ratepayers under MO1.

26714 The reduction in hydropower generation across the Pacific Northwest (a reduction of 170 aMW
26715 including Federal and non-Federal projects) results in an average annual economic cost of
26716 \$25 million when valued at the market price of the foregone power generation. However, the
26717 estimated increase in the marginal cost of producing power to meet demand based on
26718 additional average annual fixed and variable costs is \$64 million to \$170 million. If these social
26719 welfare effects persist over a 50-year timeframe, the present value cost is up to \$4.6 billion.
26720 These values are estimates of the net economic effects from a national societal perspective.

26721 Regional utilities that purchase most or all of their power from Bonneville would experience
26722 larger upward rate pressure under MO1 than IOUs or other public utilities that do not purchase

26723 Bonneville power directly. For most consumers, however, retail rates would experience slight
26724 upward rate pressure and consumers may pay more per year for electricity. Overall, MO1
26725 would result in few entities (0 percent of households and 0 to 0.5 percent of businesses,
26726 depending on the portfolio) experiencing upward rate pressure of greater than 5 percent
26727 compared to No Action. But for those entities experiencing upward rate pressure greater than
26728 5 percent, the effect would be moderate to major (Table 3-145). If the region did not acquire
26729 additional resources to replace the reduction in hydropower generation, then there would be
26730 an increase in the risk of power shortages (blackouts).

26731 **Table 3-145. Summary of Effects under Multiple Objective 1 without Additional Coal Plant**
26732 **Closures**

Effect	No Action Alternative ^{1/}	MO1 Relative to No Action
CRS Hydropower generation (aMW)	8,300	-130
Firm power of FCRPS (aMW)	7,100	-290
LOLP	6.6%	+4.6 LOLP %
Replacement resources to return LOLP to NAA level	— ^{1/}	560 MW of gas or 1,200 MW solar plus 600 MW demand response
Replacement resource cost to return LOLP to NAA level (annual cost)	— ^{1/}	+\$34 million or +\$160 million
Transmission infrastructure to return LOLP and/or transmission system reliability to NAA level (annualized reinforcement and/or interconnection cost)	— ^{1/}	\$3.8 million to \$3.9 million
Average Bonneville wholesale power rate pressure (base analysis)	\$34.56	+4.5% to +8.6%
Potential Range of Bonneville wholesale power rate (\$/MWh)		\$36.14/MWh to \$37.53/MWh
Potential range of Bonneville wholesale power rate pressure including rate sensitivities		5.6% to +14.4%
Annualized transmission rate pressure relative to NAA (%)	— ^{1/}	+0.62% to +0.74%
Average annual social welfare effects (\$): market price method estimate	—	-\$25 million
Average annual social welfare effects (\$): production cost method estimate	— ^{2/}	-\$64 million to -\$170 million
Residential rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	10.21	+0.62% to +0.74% (-0.48% to +7.6%)
Commercial rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	8.89	+0.66% to +0.77% (-0.62% to +8.2%)
Industrial rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	7.25	+0.86% +1.0% (-1.1% to +12%)
Regional Economic Productivity Effects: Change in Output	— ^{1/}	-120 million to -\$140 million

Effect	No Action Alternative ^{1/}	MO1 Relative to No Action
Regional Economic Productivity Effects: Change in Employment	— / ¹	-790 jobs to -910 jobs
Share of households experiencing >5% increase in rates relative to NAA, highest across portfolios	— / ¹	1.2%
Share of businesses with >5% increase in rates relative to NAA, highest across portfolios	— / ¹	2.1%
Regional Cost of Carbon Compliance		-\$16 to \$88 million/year

26733 Note: The estimated LOLP effect, and resulting social welfare and rate effects, rely on the best available
 26734 information regarding planned coal plant retirements as of 2017 when the modeling efforts began for this analysis.
 26735 Based on regional energy policy developments and expected coal-plant closures as of 2019, Section 3.7.3.1
 26736 discusses the sensitivity of the results of the analysis to these assumptions.

26737 1/ The analysis of the No Action Alternative for these effect categories provides a baseline against which the MOs
 26738 are compared. Thus, the No Action Alternative results presented in this table describe the baseline magnitude of
 26739 power and transmission values (e.g., for LOLP and rates) and the MO1 results describe the change relative to No
 26740 Action. A “—” indicates an effect category that is not relevant to the No Action Alternative because it only occurs
 26741 as a result of implementing the MOs (e.g., the need for new generation and transmission infrastructure and
 26742 associated costs).

26743 2/ The production cost method for valuing social welfare effects of the MOs relies on information on the fixed and
 26744 variable costs of replacement generation resources. These costs are not relevant to the No Action Alternative.

26745 The increased cost of electricity could slightly increase the costs of living and doing business in
 26746 the Pacific Northwest, resulting in adverse regional economic impacts of \$140 million in lost
 26747 output (sales) and 900 jobs.

26748 **3.7.3.4 Multiple Objective Alternative 2**

26749 This section evaluates effects under MO2. Hydropower generation would increase under MO2
 26750 and the additional generation would increase power and system reliability (i.e., reduce LOLP)
 26751 relative to the No Action Alternative. The effects of increased hydropower generation would
 26752 result in downward rate pressure on wholesale-electricity rates, market prices, and thus
 26753 downward rate pressure on retail rates for end users under MO2 relative to the No Action
 26754 Alternative.

26755 **CHANGES IN POWER GENERATION**

26756 Table 3-146 and Figure 3-181 present the generation for the No Action Alternative and MO2
 26757 and their differences by month. Overall, generation from the CRS projects would increase from
 26758 8,300 aMW under the No Action Alternative to 8,800 aMW under MO2 on average for all water
 26759 conditions. This represents an increase of 450 aMW, or a 5 percent increase in annual
 26760 generation. For the northwest U.S. system, including non-Federal projects, the increase is also
 26761 450 aMW since the gain in generation is primarily from changes in spill that only affect the CRS
 26762 projects.

26763 **Table 3-146. Monthly Electricity Generation at Columbia River System Projects under Multiple**
26764 **Objective 2, in aMW**

Month ^{1/}	NAA	MO2 Generation Difference	MO2 % Difference
October	5,500	17	0.3%
November	7,400	200	2.7%
December	8,300	350	4.3%
January	9,500	430	4.5%
February	9,700	320	3.3%
March	8,800	-280	-3.2%
April I	7,800	-160	-2.0%
April II	8,200	730	8.9%
May	10,000	1,100	11%
June	11,000	370	3.4%
July	8,800	820	9.3%
August I	7,600	1,600	22%
August II	6,500	1,500	23%
September	5,800	130	2.3%
Annual Total	8,300	450	5.3%

26765 Notes: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
26766 HYDSIM modeling inadvertently omitted the impact of the *Winter System FRM Space* in December of some years,
26767 which would move some generation (0 to 450 MW depending on the year) from January into December. This
26768 operation would not change the conclusions of the analysis.

26769 1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these
26770 months tend to have substantial natural flow differences between their first and second halves.

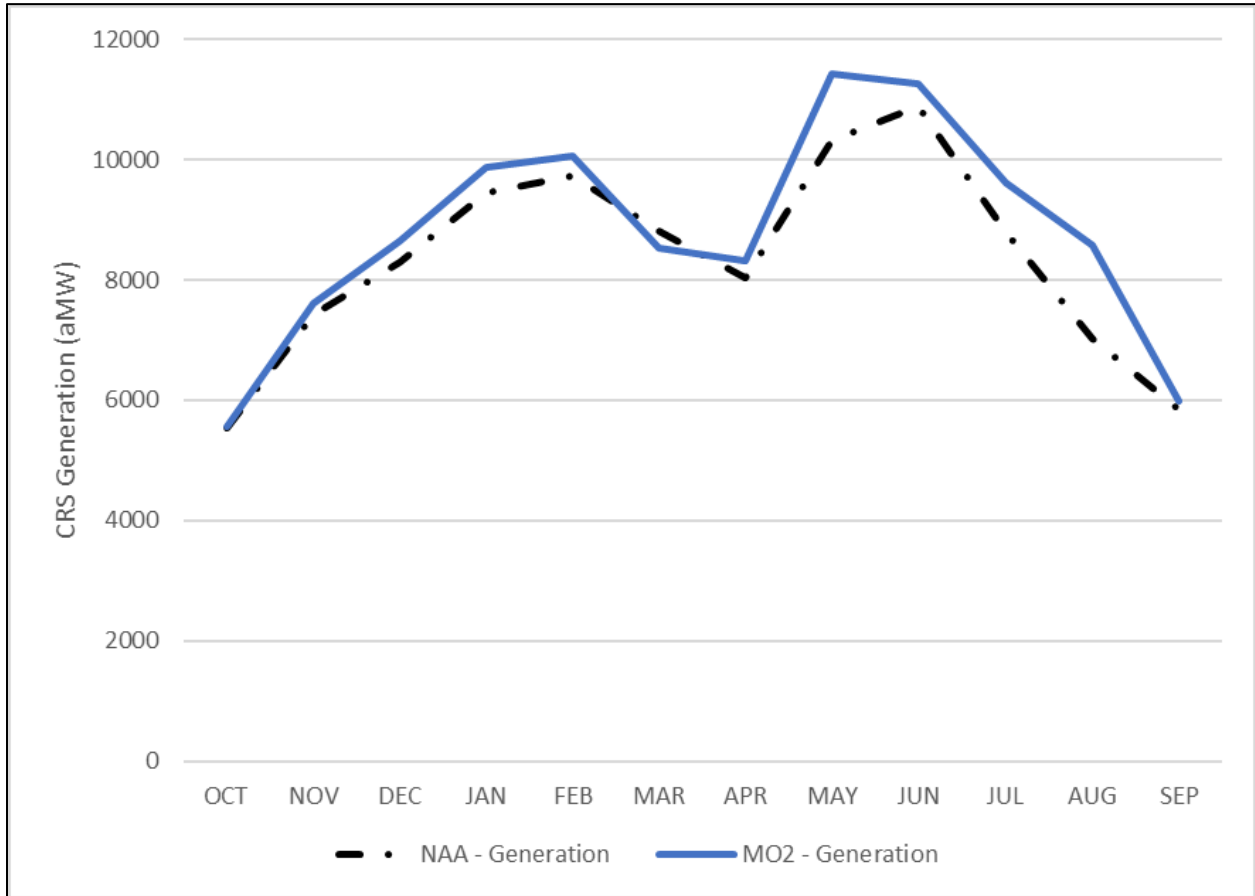
26771 Source: HYDSIM modeling results

26772 Generation would increase during most months of the year for an average water year. Two
26773 measures have the largest impact on generation in MO2 as measured in HYDSIM. The *Slightly*
26774 *Deeper Drafts for Hydropower* measure increased winter storage draft volumes and generation.
26775 *Spill to near 110% TDG* reduced volumes and duration of spill for fish passage.

26776 Under MO2, the critical water year generation of the CRS projects would increase by 6 percent
26777 (+380 aMW) compared to the No Action Alternative and the available firm power for long-term
26778 contracts would increase by 370 aMW. This increase would be largest in August when
26779 generation would increase by 20 percent due to ending summer spill. The ability of CRS projects
26780 to meet peak and heavy load periods would increase by 5 percent for both periods compared to
26781 the No Action Alternative.

26782 Other non-Federal regional hydropower projects (such as the Mid-Columbia hydro projects
26783 whose operations are hydrologically coordinated with CRS projects) would experience similar
26784 winter trends in hydropower generation to the CRS projects, but would not be impacted from
26785 changing spill at the CRS projects. The regional hydropower system (including these non-CRS
26786 projects) under MO2 would generate 14,000 aMW in an average water year. This represents a
26787 3 percent increase in power generation relative to the No Action Alternative. The CRS projects
26788 account for 445 aMW of the 453 aMW increase under MO2. Based on a qualitative assessment

26789 of the alternative, MO2 would increase the flexibility of operating the CRS projects, which
 26790 would increase the ability to integrate other renewable resources into the power grid.



26791
 26792 **Figure 3-181. Monthly Hydropower Generation at the CRS Projects, No Action Alternative and**
 26793 **Multiple Objective 2, in aMW**

26794 **EFFECTS ON POWER SYSTEM RELIABILITY**

26795 The increases in power generation under MO2 would improve power system reliability and
 26796 push out the timing of when regional resource builds would be required. The LOLP measured
 26797 under MO2 would be 5 percent. This is below the LOLP of the No Action Alternative by
 26798 1.6 percentage points and would meet the NW Council target for power system reliability.

26799 As described in Section 3.7.3.2, these LOLP estimates rely on the assumption that 4,246 MW of
 26800 coal generating capacity would continue to serve regional loads over the study period. In the
 26801 scenarios with limited or no coal generation in the region, the LOLP under MO2 would decrease
 26802 by 11 percentage points from an LOLP of 27 percent in the No Action Alternative to 16 percent
 26803 in MO2 (limited coal), and 14 percentage points in MO2 from 63 percent to 49 percent (no
 26804 coal), respectively. The difference between MO2 and the No Action Alternative is larger in the
 26805 two scenarios with the additional coal plant closures than in the base analysis, due to the loss
 26806 of baseload resources. In other words, factoring in the additional coal plant closures makes

26807 MO2 even more beneficial for regional power reliability compared to the No Action Alternative
26808 than was identified in the base analysis.

26809 **POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS**

26810 MO2 would not require replacement resources to maintain the same level of power system
26811 reliability as the No Action Alternative. MO2 has a lower LOLP than the No Action Alternative.
26812 An alternate way to assess the benefit of this additional reliability in MO2 is to identify what
26813 resources MO2 avoids building for the No Action Alternative because of the improved
26814 reliability. In the base case without additional coal plant retirements, the avoided build of new
26815 resources (i.e., the benefit of MO2 reducing LOLP) under MO2 relative to the No Action
26816 Alternative would be 440 MW of natural gas for the least-cost resource portfolio or 660 MW of
26817 wind generation in Montana, 250 MW of solar generation, and 600 MW of demand response
26818 for the zero-carbon resource portfolio. The difference in LOLP for MO2 and the No Action
26819 Alternative is influenced by the effects in winter, when solar power generates less, and wind
26820 power located in Montana was the least-cost of the zero-carbon options relative to reducing
26821 the LOLP. Because available transmission capacity from Montana appears to be about 660 MW,
26822 the portfolio considered here likewise reflects that limitation.

26823 As discussed in Section 3.7.3.2 and shown in Table 3-147, in future scenarios with limited or no
26824 coal generation no incremental zero-carbon resources would be needed to restore regional
26825 LOLP to the No Action Alternative level. That is, if MO2 were in effect, and either the limited
26826 coal capacity or the no coal capacity scenario occurred, the region would not need to acquire
26827 any more resources for MO2 than it would have otherwise acquired under the No Action
26828 Alternative.

26829 **Table 3-147. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 2 Relative to the No**
26830 **Action Alternative**

Alternative	Base Case Coal Capacity Assumption in EIS (4,246 MW)			More Limited Coal Capacity (1,741 MW)			No Coal Capacity (0 MW)		
	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Resource Build Relative to No Action (MW)	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Incremental Resource Build for MO2 as Impacted by Additional Coal Retirement (MW)	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Incremental Resource Build for MO2 as Impacted by Additional Coal Retirement (MW)
No Action	6.6%	0	0	27%	8,800	0	63%	28,000	0
MO2	5.0%	0	0	16%	5,900	0	49%	22,000	0

26831 Notes: The replacement resources for No Action include demand-response, wind, and solar.

26832 **BONNEVILLE FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION PLAN**
26833 **COSTS**

26834 Funding decisions for the Bonneville Fish and Wildlife Program are not being made as a part of
26835 the CRSO EIS process. However, Bonneville Fish and Wildlife Program costs are included in the
26836 EIS to inform a transparent cost analysis for each MO, as discussed in Section 3.19. Future
26837 budget adjustments would be made in consultation with the region through Bonneville's
26838 budget-making processes and other appropriate forums and consistent with existing
26839 agreements. In the case of MO2, Bonneville included a range of potential Fish and Wildlife
26840 Program costs to acknowledge the possibility that MO2 could have additional impacts to fish
26841 and wildlife and that this could, in turn, increase the need for some offsite mitigation funded
26842 through the Bonneville Fish and Wildlife Program. By analyzing a range of costs, Bonneville
26843 reflects the year-to-year fluctuations related to managing its Fish and Wildlife program and also
26844 acknowledges the uncertainty around both the magnitude of biological impacts and the
26845 potential impacts on funding, including the timing of funding decisions.

26846 The base case analysis in the summary rate table includes an estimate of \$316 million in annual
26847 costs (2019 dollars) for the Bonneville Fish and Wildlife Program and LSRCP together, which is
26848 consistent with the No Action Alternative. Potential increases to the Bonneville Fish and
26849 Wildlife Program, which are estimated to range up to \$53 million, are analyzed as part of the
26850 Rate Sensitivity analysis. Future budget adjustments would be made in consultation with the
26851 region through Bonneville's budget-making processes and other appropriate forums and
26852 consistent with existing agreements.

26853 **EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE**

26854 **Bonneville Interconnections**

26855 As the LOLP under MO2 would be lower than the No Action Alternative, no replacement
26856 resources would be needed, and no new interconnections or reinforcements would be
26857 required.

26858 **Bonneville Transmission System Reliability and Operations**

26859 Under MO2, Bonneville would continue to meet its transmission system reliability
26860 requirements. While average hydropower generation would increase under MO2, the peak
26861 output of the CRS projects would not increase. Since the transmission system already integrates
26862 the existing peak resource generation levels, the expected hydropower generation from MO2
26863 should not result in additional transmission system reliability issues. As a result, no additional
26864 reinforcements have been identified beyond those that are a part of Bonneville's regular
26865 system assessments.

26866 **Regional Transmission System Congestion Effects**

26867 Under MO2, due to changes in hydropower and other amounts of generation, congested hours
26868 under low runoff conditions would decrease slightly from the No Action Alternative, and
26869 congested hours under median and high runoff conditions would increase slightly.

26870 Under any runoff condition, small (less than 50 hours) changes in the number of congestion
26871 hours relative to the No Action Alternative would occur on the north-to-south paths.

26872 In both median and high runoff conditions when more hydropower generation is occurring,
26873 most west-to-east paths would experience a higher number of congested hours, the largest
26874 being the Hemingway to Summer Lake transmission paths. See Appendix H for more detailed
26875 congestion graphs.

26876 Overall, changes in the patterns of CRS generation under MO2 would have a relatively small or
26877 minor impact on congestion for most Pacific Northwest transmission paths and a minor to
26878 moderate increase in congestion hours for some west-to-east paths during median and high
26879 runoff conditions.

26880 **ELECTRICITY RATE PRESSURE**

26881 **Bonneville Wholesale Power Rates**

26882 Under MO2, the average wholesale power rate for preference customers would experience
26883 downward rate pressure relative to the No Action Alternative. Should the downward rate
26884 pressure lead to rate decreases, the expected average wholesale power rate would be
26885 \$34.28 per MWh, which represents a decrease (benefit) of \$0.28 per MWh or an 0.8 percent
26886 decrease relative to the No Action Alternative in the base case without accounting for
26887 additional coal plant retirements.

26888 The costs of structural measures at various CRS projects under MO2 would largely offset the
26889 downward rate pressure otherwise associated with the increased hydropower generation. In
26890 total, annualized structural measure costs were \$57 million per year (2019 dollars). Specifically,
26891 adding a powerhouse surface passage route at McNary Dam with a feature for collection of
26892 juvenile fish for transport accounts for nearly \$50 million in additional annual costs.⁶⁹ Without
26893 including those costs, the wholesale power rate under MO2 experiences downward rate
26894 pressure closer to \$1.3 per MWh, or 4 percent, relative to the No Action Alternative. Although
26895 MO2 also calls for installation of powerhouse surface passage structures at the Ice Harbor and
26896 John Day projects, the structures for those projects cost considerably less because they do not
26897 include fish collection facilities. If MO2 is chosen as the preferred alternative, the results of this
26898 analysis suggest that it would be much more cost effective to continue the use of fish screens
26899 and use the turbine bypass system to collect fish if transport from McNary is desired.

⁶⁹ In the other MOs, the powerhouse surface passage structure at McNary does not include fish collection facilities and is much less costly.

26900 Summary results for Bonneville’s wholesale power rate pressure analysis are presented in the
26901 first section of Table 3-148. As discussed in Section 3.7.3.1, the second section of Table 3-148
26902 provides the cost pressure (or savings) to the region of MO2 in light of potential carbon
26903 compliance and accelerated coal retirements.

26904 **Table 3-148. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 2,**
26905 **for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures**
26906 **Associated with Additional Sensitivity Analysis**

Change in Priority Firm Rate, MO2		
		Zero-Carbon Portfolio
		\$ rate pressure change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)		
1	Base Rate	\$34.28 /MWh -\$0.28 /MWh
2	Change from NAA due to Costs	\$16 0.8%
3	Change from NAA due to Load	-1.6%
4	Total Base Change in Rate	-0.8%
Rate Sensitivities (annual cost in \$ millions)		
5	Fish and Wildlife Costs	\$0 to \$53 0% to 2.5%
6	Integration Services	
7	Resource Financing Assumptions	
8	Resource Cost Uncertainties	
9	Demand Response	
10	Oversupply	\$3 to \$4 0.1% to 0.2%
11	Total Rate Sensitivities	\$3 to \$57 0.1% to 2.7%
12	Total Base Effect + Sensitivities	\$19 to \$73 -0.7% to 1.9%
Other Regional Cost Pressure (annual cost in \$ millions)		
		Zero-Carbon Portfolio
		\$ pressure change from NAA
13	Regional Cost of Carbon Compliance	-\$37 to -\$194
14	Regional Coal Retirements (capital)	\$0 to \$0
15	Regional Coal Retirements (other)	too uncertain to estimate

26907 Notes: Line 11 refers to the option of not designing powerhouse surface passage structure at McNary with an
26908 expensive feature for fish collection a more cost-effective option is available.
26909 Line 14 represents the approximate range in fixed costs for replacement resources for the more limited coal
26910 scenario and the no coal scenario. Additional changes in value, denoted by line 15, would occur from changes in
26911 market prices, changes in technology, and many other factors. Because the retirement of coal plants in the region
26912 will change the utility landscape far from the current condition, there is not enough information available to
26913 extrapolate from today’s information. Base rate includes Colville Settlement Payment, which decreases by
26914 2 percent from the No Action Alternative.
26915

26916 **Base Case Analysis**

26917 Base rate results show downward rate pressure of 0.8 percent relative to the No Action
26918 Alternative. In this alternative, no replacement resources were needed to return the region to
26919 the No Action Alternative level of LOLP. Therefore, only incremental cost pressures and load
26920 effects were analyzed. Expected cost increases of \$16 million per year (2019 dollars) put
26921 upward pressure on power rates relative to the No Action Alternative, while the increase in
26922 preference loads contributes to 1.6 percent downward rate pressure. Rate pressures are driven
26923 by higher capital costs associated with the structural measures, offset by increased generation
26924 and sales.

26925 **Rate Sensitivity Analysis**

26926 Rate sensitivities are presented in Table 3-148, lines 5 through 11 to provide quantitative
26927 estimates relative to the additional sensitivity analyses described in Section 3.7.3.1. The cost
26928 analysis showed that Bonneville's fish and wildlife expenses could be as much as \$53 million per
26929 year higher in MO2 than in the No Action Alternative, owing to higher generation and lower
26930 spill and the need for increased mitigation efforts. Because no replacement resource was
26931 selected in the LOLP, no sensitivities to resource are analyzed. OMP costs associated with
26932 oversupply events could be \$3 to \$4 million per year higher compared to the NAA.

26933 **Other Regional Cost Pressure**

26934 Cost pressures to regional utilities, which do not necessarily impact Bonneville's power rates,
26935 but could in the future, are presented in lines 13 and 14. Effects associated with regional
26936 carbon compliance laws are unknown, pending current legislation in Oregon and Washington as
26937 discussed in Section 3.7.3.1. If binding estimates effective in the future are enforced to the
26938 resource portfolio in MO2, regional utilities could face cost savings relative to the No Action
26939 Alternative of \$37 to 194 million per year.

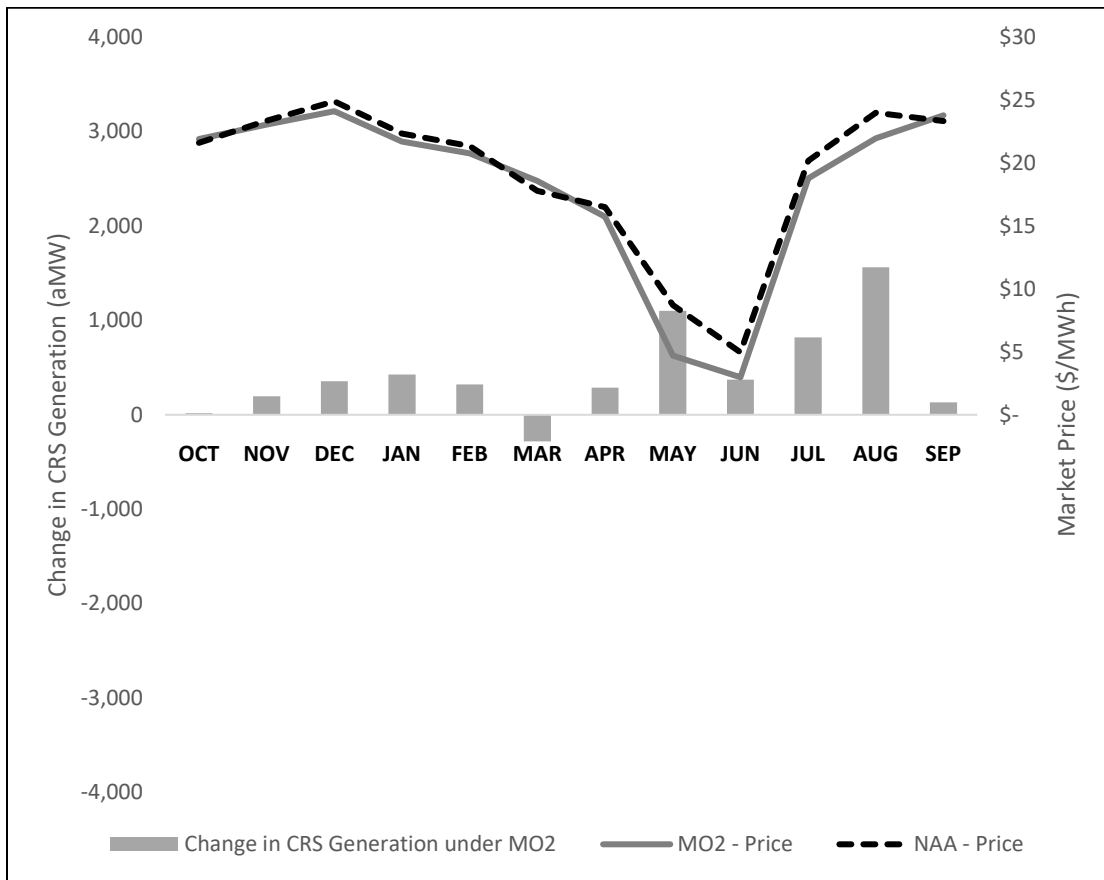
26940 As described in Sections 3.8.3.1, Availability of Coal Resources subsection, and 3.8.3.2, Effects
26941 on Power System Reliability subsection, regional utilities would need to add 8,800 MW of
26942 additional zero-carbon resources in the limited coal capacity scenario and 28,000 MW of
26943 additional zero-carbon resources in the no coal scenario to maintain regional LOLP at No Action
26944 Alternative levels (6.6 percent). Lines 14 and 15 estimate the incremental zero-carbon
26945 resources costs needed by the region to maintain the No Action Alternative LOLP of at least
26946 6.6 percent under MO2 in light of a limited or no coal assumption. An "incremental zero-carbon
26947 resource cost" occurs if the combination of (1) the resources Bonneville or the region is
26948 expected to acquire under the MO, plus (2) 8,800 MW (under the limited coal scenario) or
26949 28,000 MW (under the no coal scenario), is less than the total amount of zero-carbon resources
26950 needed to return the region to the No Action Alternative LOLP of 6.6 percent.

26951 For the limited coal capacity scenario under MO2, a minimum of 5,900 MW of zero-carbon
26952 resources would need to be added by the region to maintain regional LOLP at the No Action
26953 Alternative level of 6.6 percent. For the no coal scenario under MO2, a minimum of 22,000 MW

26954 of zero-carbon resources would be needed to maintain regional LOLP to No Action Alternative
 26955 levels. Since both of these starting values are below the No Action Alternative’s 8,800 MW (for
 26956 limited coal) and 28,000 MW (for no coal), no incremental zero-carbon resource costs would be
 26957 incurred as a result of this MO under either a limited or no coal scenario.

26958 **Market Prices**

26959 Market prices would be expected to experience downward price pressure, potentially leading
 26960 to decreases in price to \$18.77 per MWh under MO2 due to the increase in hydropower
 26961 generation and additional surplus power (2019 dollars). This effect would be a decrease of
 26962 \$0.65 per MWh or 3.3 percent relative to the No Action Alternative. Figure 3-182 presents the
 26963 CRS projects’ generation and the market prices under MO2 for the average of the 80 historical
 26964 water years. Prices would peak in September when generation is low, while prices would be
 26965 lowest in May and June when generation exceeds 11,000 aMW.



26966 **Figure 3-182. Market Prices and Average CRS Hydropower Generation for the Base Case**
 26967 **without Additional Coal Plant Retirements**
 26968

26969 Note: The right axis is the market price (\$/MWh). The left axis is generation from the CRS projects by month
 26970 (aMW).

26971 Source: Power Analysis

26972 **Bonneville Wholesale Transmission Rate Pressure**

26973 Under MO2, there would be no changes in capital investments or long-term transmission sales.
26974 The upward Bonneville transmission rate pressure would be about 0.11 percent annually
26975 (0.89 percent cumulatively over an 8-year period) relative to the No Action Alternative because
26976 transmission short-term sales would likely change as a result of the changes in hydropower
26977 generation and associated market pricing. For specific customers and product choices, the
26978 annualized upward rate pressure ranges from 0.05 to 0.23 percent.

26979 **Retail Rate Effects**

26980 Under MO2, retail electricity rates (paid to individual utilities) would remain similar to the No
26981 Action Alternative. Some counties would experience small increases while others would
26982 experience decreases in the electricity retail rate. Across the Pacific Northwest, changes to the
26983 retail rate would range from -0.092 cents to +0.042 cents per kWh for residential end users.
26984 For commercial end users, rate effects range from -0.092 cents to +0.038 cents per kWh, and
26985 for industrial customers, from -0.093 cents per kWh to +0.034 cents per kWh, relative to the No
26986 Action Alternative.

26987 **BONNEVILLE FINANCIAL ANALYSIS**

26988 As previously described, the Bonneville financial analysis considers the effects of the MOs on
26989 future cash flows over a 30-year financing period for potential replacement resources.
26990 For MO2, the NPV of the cash flow effects are described in Table 3-149. This NPV analysis is
26991 Bonneville specific and does not capture wider societal impacts. This NPV analysis uses a risk
26992 adjusted discount rate of 7.9 percent and a 30-year timeframe.

26993 The sensitivities in this analysis are described in the Power Rates section, above.

26994 **Table 3-149. Bonneville Financial Analysis Results (in Millions \$2022)**

Analysis Type	MO2 Zero-Carbon
Power	-\$453
Transmission	-\$10
Total Base Impact – Bonneville	-\$464

26995 **SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION**

26996 Except where noted, this section describes the base analysis for MO2 without considering the
26997 range of additional costs shown in Table 3-148 and without the retirement of additional coal-
26998 plants.

26999 **Social Welfare Effects**

27000 This social welfare analysis employs both the market price and production cost methods based
27001 on the base case for this analysis, assuming no additional coal plant retirements. Section
27002 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*, describes the differences

27003 between these two methods. Table 3-150 presents the market value of the increase in Pacific
27004 Northwest hydropower generation under MO2 as compared with the No Action Alternative.
27005 Based on the market price method, the average annual economic effect of MO2 is a \$75 million
27006 benefit. If these social welfare effects persist over a 50-year timeframe, the present value
27007 benefit would be \$2.0 billion.

27008 **Table 3-150. Average Annual Social Welfare Effect of Multiple Objective 2 Based on the**
27009 **Market Price of Changes in Pacific Northwest Hydropower Generation (2019 U.S. Dollars)**

Change in Generation (aMW)	Change in Generation (MWh)	Average Annual Social Welfare Effect
+450	+4,000,000	\$75,000,000

27010 Table 3-151 evaluates the social welfare effects of MO2 in terms of the reduction in the costs of
27011 producing power due to the increased hydropower generation presented in Table 3-146.
27012 The social welfare effects are the reduction in the cost of fuel for fossil fuel-based generation
27013 due to the increased generation from hydropower under MO2 relative to No Action Alternative.
27014 The effects do not include the value of any improvement in the level of power system reliability
27015 associated with replacement resources under MO2, because MO2 does not require such
27016 resources. Based on this approach, the social welfare effect of MO2 is an average annual
27017 benefit of \$55 million. If these social welfare effects persist over a 50-year timeframe, the
27018 present value benefit would be \$2.2 billion. The resource portfolio equivalent to the
27019 improvement in power system reliability from the No Action Alternative to MO2 would have a
27020 value ranging up to \$170 million. In the future scenarios of additional coal plant retirements,
27021 the value of MO2 increases.

27022 **Table 3-151. Average Annual Social Welfare Effect of Multiple Objective 2 Based on the**
27023 **Reduced Cost of Producing Power to Meet Demand (2019 U.S. Dollars)**

Production Cost Factor ^{1/}	Cost
Annualized Fixed Cost of Replacement Resources	\$0
Annualized Fixed Cost of Transmission Infrastructure	\$0
Average Annual Variable Costs	\$82,000,000
Average Annual Social Welfare Costs	\$82,000,000

27024 Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
27025 1/ Positive values in the table represent a decrease (net benefit) in the cost of producing power.

27026 **Regional Economic Effects**

27027 Under MO2, retail electricity rate effects would range from beneficial to adverse effects across
27028 the region. The average residential retail rate would experience downward rate pressure of a
27029 fraction of a cent per kWh, and average commercial and industrial rates would experience
27030 downward rate pressure of a fraction of a cent per kWh, such that the net effect would result in
27031 beneficial socioeconomic effects relative to the No Action Alternative.

27032 Residential Effects

27033 Residential retail rates would experience downward rate pressure across a large share of the
27034 counties in the Pacific Northwest under MO2. On average, residential rates would experience
27035 downward rate pressure, and the largest upward rate pressure would be 0.042 cents per kWh.
27036 Residential retail rate pressures under MO2 would range from a 1 to 0.46 percent increase to a
27037 1.3 percent decrease. In addition, in the scenarios with limited or no coal in the region, there
27038 would be further downward rate pressure in MO2 than the No Action Alternative because the
27039 benefit to the power system of additional generation under MO2 would reduce the need to
27040 build new generating capacity.

27041 Both urban areas and rural areas would potentially benefit from downward rate pressure under
27042 MO2 with the largest decrease occurring in urban counties with fewer than 20,000 residents
27043 and metro areas with fewer than 250,000 residents (residential rate decreases between -0.56
27044 and -0.54 percent). CRSO Regions A, D and “other” would experience the largest average
27045 downward in residential rate pressure of 0.40 percent, 0.37 percent, and 0.40 percent
27046 (Table 3-152).

27047 **Table 3-152. Average Residential Rate Pressure by Columbia River System Operations Region**

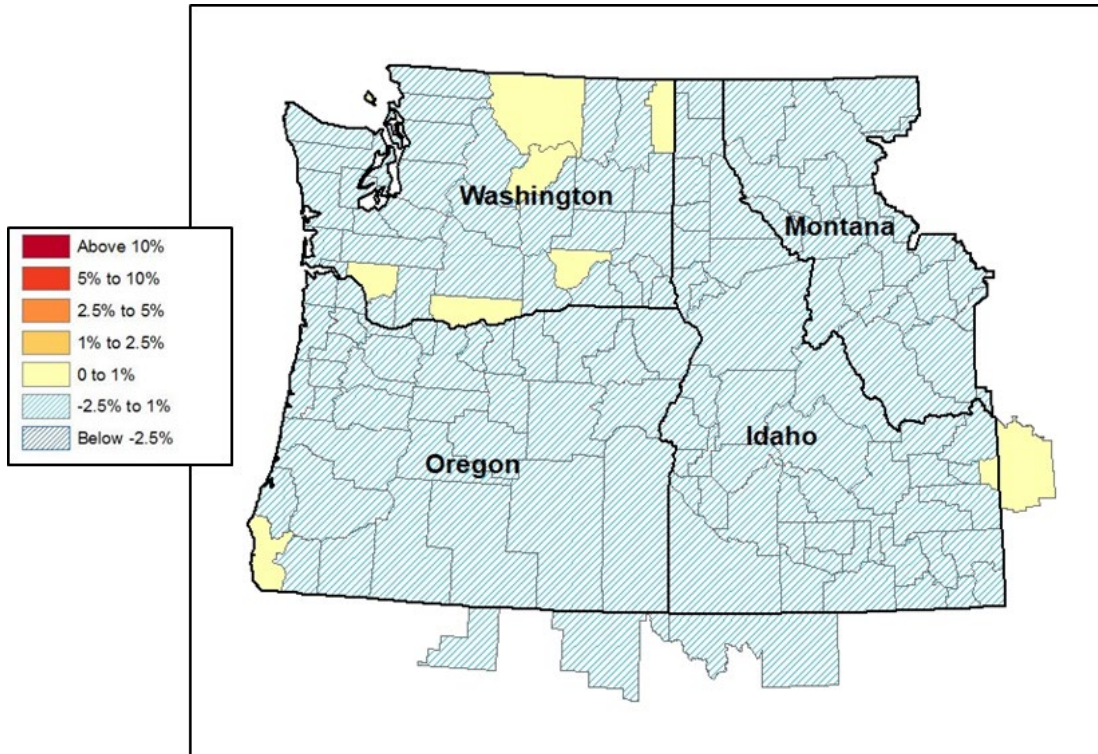
CRSO Region	MO2 Average Residential Rate Pressure Relative to NAA
Region A	-0.40%
Region B	-0.32%
Region C	-0.34%
Region D	-0.37%
Other	-0.40%

27048 Figure 3-183 presents the estimated change in retail rates on a geographic basis relative to the
27049 No Action Alternative. As illustrated in this figure, the residential retail rates experience
27050 downward rate pressure across much of the region with a few counties that experience upward
27051 effects.

27052 To the extent that the downward rate pressure leads to changes in rates, end users would
27053 decrease spending on electricity (Table 3-153). As a percentage of income across the region,
27054 income for the average household under MO2 would also increase mildly relative to the No
27055 Action Alternative by less than 0.05 percent. Some households would experience benefits with
27056 reductions of up to 1.7 percent of their expenditures on electricity. Roughly three percent of all
27057 households in the region would experience increases between 0 and 1 percent in their average
27058 electricity expenditures while 97 percent would experience beneficial decreases in their
27059 average expenditures.

27060 Given the relatively small changes in rates, the effects on the demand for electricity would also
27061 likely be small. Residential end users could adjust their consumption based on changes between
27062 -1.3 and 0.46 percent, varying by the county rate effect. These consumption decisions in MO2
27063 would lead to a range of effects across counties with households either saving up to \$4.5 per
27064 year or consuming more electricity and spending \$9.5 more per year for the highest and lowest

27065 rate changes. On average, households would experience a less than 1 percent change with
27066 annual savings of less than \$1. The total decrease in household spending on electricity across all
27067 Pacific Northwest households would be \$24 million per year under Multiple Objective 2.



27068
27069 **Figure 3-183. Residential Rate Pressure Effects under MO2 Relative to the No Action**
27070 **Alternative**

27071 **Table 3-153. Percentage of Residential End Users Who Experience Changes in Electricity**
27072 **Expenditures by Size of Expenditure Change in each Portfolio under Multiple Objective 2**

Sector	Expenditure Change	MO2
Residential	>+10%	0%
	+5 to 10%	0%
	+2.5 to 5 %	0%
	+2.5% to 1%	0%
	+0% to 1%	2.9%
	Decrease	97%

27073 MO2 contained an expensive variation of a powerhouse surface passage structure at McNary
27074 dam that could also collect fish for transportation. If MO2 were implemented with fish
27075 collection at McNary, a significantly cheaper option would be likely be implemented. Not
27076 including the costly structure at McNary Dam would increase the power value MO2. Similarly,
27077 the scenarios with limited or no coal would each increase the power value of the MO2 relative
27078 to the No Action Alternative and would decrease the power rates and expenditures relative to
27079 the No Action Alternative.

27080 This analysis considers how the region-wide changes in household spending on electricity would
 27081 affect demand for other goods and services across the region. That is, under MO2 the
 27082 decreased spending on electricity may increase spending on other items, affecting regional
 27083 economic productivity. This analysis applies IMPLAN to model the decreased spending on
 27084 electricity as an increase in household income (direct effect), and quantifies the multiplier
 27085 effects on interrelated economic sectors (indirect and induced effects). This analysis finds that
 27086 the potential decreased cost of household electricity would result in gains of \$25 million in
 27087 regional output (sales) and 170 jobs (Table 3-154). The majority of regional economic effects
 27088 would occur Washington and Oregon.

27089 **Table 3-154. Regional Economic Effects from Decreases in Household Spending on Electricity**
 27090 **under Multiple Objective 2**

Effect	MO2
Output	+ \$25 million
Value Added	+ \$15 million
Labor Income	+ \$8.3 million
Employment	+170 jobs

27091 Note:1/ Positive values in the table represent an increase (net benefit) in the output and employment of the
 27092 regional economy

27093 **Commercial and Industrial Effects**

27094 Under MO2, commercial and industrial rates would experience downward rate pressure for a
 27095 majority of end users with small upward effect in some counties. Average commercial and
 27096 industrial end users would experience a 0.48 percent decrease and 0.58 percent increase,
 27097 respectively. The counties with the largest number of commercial entities would experience a -
 27098 0.72 to -0.12 percent downward commercial rate pressure effect. For industrial end users, the
 27099 average retail rate in these counties under MO2 would also experience a downward pressure
 27100 effect, by -0.26 percent to -1.0 percent relative to the No Action Alternative.

27101 For the average industrial end user, MO2 would result in expenditures not changing noticeably
 27102 compared to the No Action Alternative. For the average end user, MO2 would result in slightly
 27103 lower expenditures for industrial users, by 0.58 percent, and slightly lower expenditures for
 27104 commercial users, by 0.48 percent, compared to the No Action Alternative. A majority
 27105 (98 percent) of industrial customers would experience decreases in their expenditures and a
 27106 majority (97 percent) of commercial end users would experience a downward rate pressure in
 27107 their retail rates. The largest single-county reduction in industrial expenditures on electricity is
 27108 \$2,800, or 1.1 percent of No Action Alternative levels. Table 3-155 presents the fraction of
 27109 commercial and industrial end users that would experience increases in expenditures above
 27110 certain thresholds under MO2 compared to the No Action Alternative.

27111 For MO2, no commercial or industrial end users would experience increases above 2.5 percent
 27112 relative to the No Action Alternative. The majority of users would face a decrease. Without the
 27113 costly fish-collection structure at and McNary Dam, rates would likely decrease in all categories.

27114 Similarly, in the scenarios with limited or no coal, the rates would likely decrease relative to the
27115 No Action Alternative.

27116 **Table 3-155. Percentage of Commercial and Industrial End Users Who Experience Changes in**
27117 **Electricity Expenditures by Size of Expenditure Change under Multiple Objective 2**

Sector	Expenditure Change	MO2
Commercial	>+10%	0%
	+5 to 10%	0%
	+2.5 to 5 %	0%
	+2.5% to 1%	0%
	+0% to 1%	3.9%
	Decrease	96%
Industrial	>+10%	0%
	+5 to 10%	0%
	+2.5 to 5 %	0%
	+2.5% to 1%	0%
	+0% to 1%	2.2%
	Decrease	98%

27118 Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

27119 Under MO2, the total potential decrease in spending on electricity across commercial
27120 businesses in the Pacific Northwest would be \$8.0 million per year. This analysis uses the
27121 IMPLAN model to quantify the multiplier effects of the change in commercial sector
27122 productivity (Table 3-156). The multiplier effects reflect how the decreased costs of doing
27123 business affect demand for inputs to production across commercial businesses. This analysis
27124 finds that the decreased cost of electricity to regional commercial businesses would result in
27125 potential gains of \$14 million in regional output (sales) and 97 jobs. The majority of regional
27126 economic effects would occur Washington and Oregon.

27127 **Table 3-156. Regional Economic Effects from Decreases in Commercial Business Spending on**
27128 **Electricity under Multiple Objective 2**

Effect	MO2
Output	+\$14 million
Value Added	+\$8.3 million
Labor Income	+\$4.3 million
Employment	+97 jobs

27129 1/ Positive values in the table represent an increase (net benefit) in the output and employment of the regional
27130 economy

27131 Under MO2, the total potential decrease in spending on electricity across industrial businesses
27132 in the Pacific Northwest would be \$26 million. Similar to the commercial spending analysis, the
27133 IMPLAN model is used to quantify the multiplier effects of the change in industrial sector
27134 productivity (Table 3-157). This analysis finds that the decreased cost of electricity to regional

27135 industrial businesses could result in the gain of \$44 million in regional output (sales) and
27136 30 jobs. Again, the majority of regional economic effects would occur Washington and Oregon.

27137 **Table 3-157. Regional Economic Effects from Decreases in Industrial Business Spending on**
27138 **Electricity under Multiple Objective 2**

Effect	MO2
Output	+\$44 million
Value Added	+\$27 million
Labor Income	+\$14 million
Employment	+300 jobs

27139 Note:1/ Positive values in the table represent an increase (net benefit) in the output and employment of the
27140 regional economy

27141 **Other Social Effects**

27142 Under MO2, expenditures on residential electricity would change very slightly and would be
27143 reduced for many households. Based on the expected rate decreases or small increases, MO2
27144 would be unlikely to create an energy burden on household consumers and would not be
27145 expected to cause households to forego expenditures due to changes in electricity bills. Under
27146 MO2, no reliability effects would occur and LOLP would improve relative to the No Action level
27147 so that the reduced risk of safety concerns related to power outages would be a beneficial
27148 effect compared to the No Action Alternative.

27149 **SUMMARY OF EFFECTS**

27150 Under MO2, hydropower generation would increase relative to the No Action Alternative, and
27151 the FCRPS would gain 370 aMW of firm power available for long-term firm power sales (roughly
27152 the amount of power consumed by about 300,000 Northwest homes in a year). The increase in
27153 hydropower generation would reduce LOLP, improve power system reliability, and lower
27154 electricity costs.

27155 The increase in hydropower generation across the Pacific Northwest (an increase of 450 aMW
27156 including Federal and non-Federal projects) results in an average annual economic benefit of
27157 \$75 million when valued at the market price of power generation. The estimated reduction in
27158 the marginal cost of producing power to meet demand is \$82 million. If these social welfare
27159 effects persist over a 50-year timeframe, the present value benefit would be up to \$2.2 billion.
27160 These values are estimates of the net economic benefits of MO2 from a national societal
27161 perspective.

27162 Both residential and commercial end users would experience minor downward rate pressure
27163 effects up to a decrease of 2 percent to minor upward effects of below 1 percent in average
27164 rates. A minority of end users would experience upward rate pressure effects under MO2.

27165 The decreased cost of electricity would decrease spending on electricity for households and
27166 businesses resulting in a gain of \$82 million in output (sales) and 560 jobs in the region. Without
27167 the costly fish-collection structure at McNary Dam, rates would likely lower further in all

27168 categories. Similarly, in the scenarios with limited or no coal, the rates would likely decrease in all
27169 categories relative to the No Action Alternative (Table 3-158). Regional utilities that purchase most or all of
27170 their power from Bonneville could experience larger effects than IOUs or other public utilities
27171 that do not purchase Bonneville power directly.

27172 **Table 3-158. Summary of Effects under Multiple Objective 2 without Additional Coal Plant**
27173 **Closures**

Effect	No Action Alternative ^{1/}	MO2 Relative to No Action
CRS Hydropower generation (aMW)	8,300	+450
Firm power of FCRPS (aMW)	7,100	+370
LOLP	6.6%	-1.6 LOLP %
Replacement resources to return LOLP to NAA level	— ^{1/}	Avoided build of 440 MW of gas or 250 MW solar, 660 MW MT wind, and 600 MW demand response ^{2/}
Replacement resource cost to return LOLP to NAA level (annual cost)	— ^{1/}	-\$19 million to -\$140 million ^{2/}
Transmission infrastructure to return LOLP and/or transmission system reliability to NAA level (annualized reinforcement and/or interconnection cost)	— ^{1/}	— ^{2/}
Average Bonneville wholesale power rate pressure (base analysis)	\$34.56	-0.8% ^{3/} \$34.28/MWh
Potential Bonneville wholesale power rate (\$/MWh)		-0.7% to +1.9%
Potential range of Bonneville wholesale power rate pressure including rate sensitivities		
Annualized transmission rate pressure relative to NAA (%)	— ^{1/}	+0.11%
Average annual social welfare effects (\$): market price method estimate	—	+\$75 million ^{2/}
Average annual social welfare effects (\$): production cost method estimate	— ^{4/}	+\$82 million
Residential rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	10.21	-0.39% (-1.3% to +0.46%)
Commercial rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	8.89	-0.48 % (-2.0% to +0.46%)
Industrial rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	7.25	-0.58% (-2.4% to +0.57%)
Regional Economic Productivity Effects: Change in Output	— ^{1/}	+\$82 million
Regional Economic Productivity Effects: Change in Employment	— ^{1/}	+560 jobs
Regional Cost of Carbon Compliance		-37 to -194 million/year

27174 Note: The estimated LOLP effect, and resulting social welfare and rate effects, rely on the best available
27175 information regarding planned coal plant retirements as of 2017 when the modeling efforts began for this analysis.
27176 Based on regional energy policy developments and expected coal-plant closures as of 2019, Section 3.7.3.1
27177 discusses the sensitivity of the results of the analysis to these assumptions.

27178 1/ The analysis of the No Action Alternative for these effect categories provides a baseline against which the MOs
27179 are compared. Thus, the No Action Alternative results presented in this table describe the baseline magnitude of
27180 power and transmission values (e.g., for LOLP and rates) and the MO2 results describe the change relative to No
27181 Action. A “—” indicates an effect category that is not relevant to the No Action Alternative because it only occurs
27182 as a result of implementing the MOs (e.g., the need for new generation and transmission infrastructure and
27183 associated costs).
27184 2/ MO2 is assumed to result in avoidance of a need to build additional resources that would have been anticipated under
27185 the No Action Alternative. As such, replacement resource costs are negative, and social welfare effects are positive.
27186 3/ This value would be -4 percent without the new McNary fish collection structure. That is, without the structure,
27187 wholesale rates under MO2 would be 4 percent lower than under the No Action Alternative.
27188 4/ The production cost method for valuing social welfare effects of the MOs relies on information on the fixed and
27189 variable costs of replacement generation resources. These costs are not relevant to the No Action Alternative.

27190 **3.7.3.5 Multiple Objective Alternative 3**

27191 This section evaluates effects under MO3. Losing generation due to breaching the lower Snake
27192 River projects and the increase in spring spill for juvenile fish passage under this alternative
27193 would reduce overall power generation and power system reliability. The loss of generation
27194 would also change flows on the transmission system. Replacement resources to bring LOLP to
27195 No Action Alternative levels would result in upward rate pressure under MO3 relative to the No
27196 Action Alternative.

27197 In MO1, MO2, and MO4, operational changes impact the amount of power produced, but do
27198 not make major changes to the generating resources. MO3 removes generating resources from
27199 the system. As such, a number of metrics are relevant for MO3 that are not included in the
27200 effects analysis for the other MOs. These include an assessment of the debt still outstanding
27201 associated with the lower Snake River projects, the reduced capital, and large changes to
27202 operations and maintenance at the projects. Another contrast between MO3 and the other
27203 MOs pertains to the loss of the ability to generate from these projects in unforeseen and
27204 emergency conditions.

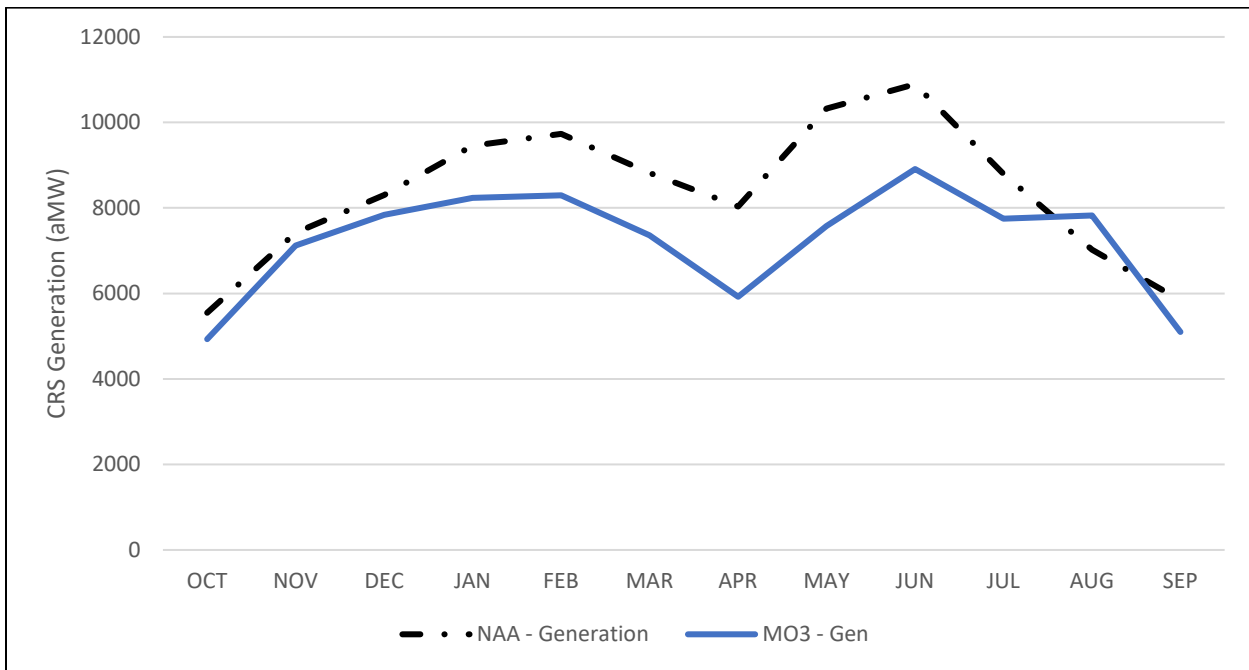
27205 **CHANGES IN POWER GENERATION**

27206 Table 3-159 and Figure 3-184 present the generation for the No Action Alternative and MO3
27207 and their differences by month. Overall, generation from the CRS projects would decrease by
27208 1,100 aMW from 8,300 aMW under the No Action Alternative to 7,200 aMW under MO3, on
27209 average, over all historical water conditions. This represents a greater than 13 percent decrease
27210 in generation. For the regional hydropower system, including the non-Federal projects, the
27211 decrease in generation would be 1,140 aMW. This represents a greater than 9 percent decrease
27212 in the U.S. regional generation. Generation would decrease throughout most of the year with
27213 the largest decreases in the winter, spring, and early summer months. Because generation from
27214 the lower Snake River projects would be eliminated under MO3, when compared to the No
27215 Action Alternative, this lack of generation generally accounts for these decreases. This is
27216 particularly true in the winter, spring, and early summer months when the lower Snake River
27217 projects typically generate the most power. Generation would also be diminished by increased
27218 fish passage spill at the lower Columbia River projects in the spring. Generation would increase
27219 in August as a result of ending fish passage spill at the lower Columbia River projects earlier
27220 than under the No Action Alternative.

27221 **Table 3-159. Monthly Hydropower Generation at the Columbia River System Projects,**
27222 **Multiple Objective 3 Relative to the No Action Alternative, in aMW**

Month ^{1/}	NAA	MO3 Generation Difference	MO3 % Difference
October	5,500	-620	-11%
November	7,400	-300	-4%
December	8,300	-460	-6%
January	9,500	-1,200	-13%
February	9,700	-1,400	-15%
March	8,800	-1,500	-17%
April I	7,800	-1,900	-24%
April II	8,200	-2,400	-29%
May	10,000	-2,700	-27%
June	11,000	-2,000	-18%
July	8,800	-1,000	-12%
August I	7,600	800	11%
August II	6,500	800	12%
September	5,800	-740	-13%
Annual Total	8,300	-1,100	-13%

27223 1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these
27224 months tend to have substantial natural flow differences between their first and second halves.
27225 Source: HYDSIM modeling results



27226 **Figure 3-184. Monthly Hydropower Generation at the Columbia River System Projects, No**
27227 **Action Alternative and Multiple Objective 3, in aMW**
27228

27229 Under MO3, the critical water year generation of the CRS projects would decrease by
27230 12 percent (-750 aMW, from 6,200 aMW to 5,500 aMW) and the available firm power for long-

27231 term contracts would decrease by 730 aMW. This decrease would be largest in May when
27232 generation would decrease by 38 percent. The ability of CRS projects to meet peak load and
27233 heavy load periods would decrease by 11 percent and 9 percent, respectively.

27234 Non-Federal hydropower projects that are located downstream of CRS projects (such as the
27235 mid-Columbia hydro projects) would not experience the effects in hydropower generation from
27236 dam breaching and spill changes. They would, however, experience effects from measures that
27237 alter flows in the upper- and mid-Columbia River such as changes in water management at
27238 Libby and additional irrigation withdrawals. The regional hydropower system (including certain
27239 non-CRS projects) under MO3 would generate 12,000 aMW, on average, over all modeled
27240 water years. This represents a 9 percent decrease in power generation relative to the No Action
27241 Alternative. The CRS projects account for 97 percent of the decrease under MO3.

27242 Based on a qualitative assessment of the alternative, MO3 includes measures that increase and
27243 measures that decrease the flexibility of the hydro-system. This flexibility is useful to integrate
27244 the variability of other renewable resources. The loss of generation at the lower Snake River
27245 projects and the increase in spill at the lower Columbia River projects reduces flexibility
27246 considerably. Conversely, allowing John Day to use a wider forebay operating range during the
27247 fish passage season, allowing the turbines to operate over a wider range and carrying
27248 contingency reserves within fish spill help to partially offset the reduction in flexibility.

27249 **EFFECTS ON POWER SYSTEM RELIABILITY**

27250 Due to the reduction in total hydropower generation under MO3, the LOLP under MO3 would
27251 be 14 percent, which is 7.3 percentage points higher LOLP than under the No Action
27252 Alternative, more than doubling the chances of a power shortage in the region. The change in
27253 LOLP results from changes in generation throughout most of the year from the loss of
27254 generation from the lower Snake River projects and increased spring spill at the lower Columbia
27255 River projects and increased irrigation withdrawals. There is an increase in generation in August
27256 due to the earlier end of summer spill at the lower Columbia River projects. A 14 percent LOLP
27257 is roughly equivalent to a one-in-seven likelihood of one or more loss of load events (such as a
27258 power outage) in 2022, more than double the LOLP under the No Action Alternative.

27259 As described in Section 3.7.3.2, these LOLP estimates rely on the assumption that 4,246 MW of
27260 coal generating capacity would continue to serve regional loads over the study period. In future
27261 scenarios with limited to no coal capacity, the LOLP under MO3 would increase by
27262 16 percentage points relative to the No Action Alternative, depending on how much coal-fired
27263 generation remains in the region (from 27 percent to 43 percent in the limited coal scenario
27264 and from 63 percent to 79 percent with no coal). In the scenario with additional coal closures,
27265 the LOLP for the No Action Alternative is well above the NW Council target of 5 percent.
27266 Further, the difference between MO3 and the No Action Alternative is larger in the two
27267 scenarios with the additional coal closures than in the base analysis due to the loss of baseload
27268 resources with the retirement of additional coal plants. In other words, factoring in the
27269 additional coal plant closures causes MO3 to have a substantially more negative impact for
27270 regional power system reliability than was identified in the base analysis.

27271 **POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS**

27272 To maintain power system reliability in the Northwest, additional generation resources would
27273 be needed. As with other MOs, two replacement resource portfolios were considered in the
27274 base case analysis to return regional LOLP to the No Action Alternative of 6.6 percent:
27275 (1) conventional least-cost; and (2) zero-carbon. Each is described in more detail below.

27276 **Conventional Least-Cost Replacement (Base Case Analysis)**

27277 Under the least-cost replacement generation portfolio, returning LOLP to the No Action
27278 Alternative level could be accomplished with approximately 1,120 MW of combined cycle
27279 natural gas turbines located in northeastern Oregon in a base case without additional coal
27280 closures. This portfolio would cost approximately \$137 million annually including annualized
27281 capital costs, fixed operations and maintenance, fixed fuel transmission and insurance (2019
27282 dollars). The annual cost of fuel to generate power would vary depending on annual power
27283 production. During critical water conditions, the fuel plus variable operations and maintenance
27284 costs would be roughly \$112 million annually (2019 dollars).⁷⁰ If the lost generation is replaced
27285 by natural-gas fired power plants, then the replacement resources would not only return the
27286 LOLP to the same level as the No Action Alternative, but would also replace flexibility and base-
27287 load value of the generation lost due to dam breach in MO3.

27288 **Zero-Carbon Replacement (Base Case Analysis)**

27289 Under the zero-carbon replacement portfolio, approximately 2,550 MW of solar power
27290 resources and 600 MW of demand response would be needed to reduce regional LOLP to the
27291 No Action Alternative level. Operating with this replacement portfolio would also require
27292 increased generation from the existing gas and coal-fired plants in the region. The transmission
27293 analysis assumed solar resources would be located in central Oregon based on proposed
27294 projects in the generation interconnection queue as well as that being a location with high solar
27295 output. To provide a sense of scale, the region currently has about 1,000 MW of solar. These
27296 new solar-power resources would require roughly 14,000 acres (about 22 square miles) of land.
27297 Such a large build out of solar capacity would likely result in additional but currently unknown
27298 impacts to natural and cultural resources, which may include vegetation, wildlife habitat,
27299 archeological resources, and traditional cultural properties.

27300 In addition to 2,550 MW of solar, analysis was conducted to determine whether other
27301 resources would be needed to replace the lost flexibility and generating capability of the lower
27302 Snake River projects. This additional step was developed in the latter stages of the base case
27303 analysis for MO3 to reflect that the lower Snake River projects would no longer be available to
27304 support regional power needs, including peaking capability, reserves, voltage support, inertia,
27305 and emergency service. The lower Snake River projects provide on average 1,000 aMW of

⁷⁰ These higher fuel costs that would result in MO3 are explained by the selection of combined-cycle turbines for gas-fired power generation that would run more consistently to offset lost generation in the lower Snake River projects, compared to the selection of single-cycle turbines in MO1 and MO4.

27306 hydropower generation, more than 2,000 MW of sustained peaking capabilities during the
27307 winter, and a quarter of Bonneville’s current reserves holding capability. Adding 2,550 MW of
27308 solar, though sufficient to return regional LOLP to the No Action Alternative levels, would not
27309 replace the lost capacity and flexibility benefits provided by the lower Snake River projects to
27310 regional reliability and stability. The infusion of new intermittent renewable resources to
27311 replace lost generation from the lower Snake River projects would further stress the limited
27312 ramping capabilities and generation balancing reserves of the remaining CRS and other power
27313 plants in the region. Regional demand for ramping and generation services would, then, likely
27314 cause development of additional flexibility resources to replace the lost lower Snake River
27315 projects’ capability. That demand would grow as the retirement of regional coal resources
27316 accelerates and state policies make replacing coal with natural gas less acceptable.

27317 Developing a zero-carbon portfolio that would replace all attributes of the lower Snake River
27318 projects for the base case analysis was not possible given the time constraints with this analysis.
27319 Nonetheless, to reflect a portion of the costs of replacing the lost capability and flexibility of the
27320 lower Snake River projects under MO3, the base case analysis assumes that half of the 2,550
27321 MW in installed solar capacity (1,275 MW) would be supported by battery or solar storage.
27322 Estimates for the costs of solar storage installation came from recent cost estimates from the
27323 NW Council.⁷¹ The analysis returns a part of the lost flexibility in the base case analysis as a first
27324 step to developing a zero-carbon portfolio to replace the full capability of the lower Snake River
27325 projects. As discussed below, a more in-depth review of a zero-carbon replacement portfolio is
27326 developed in the lower Snake River replacement analysis.

27327 Under the base case analysis, the zero-carbon portfolio of 2,550 MW of solar plus 1,275 MW of
27328 storage would cost \$389 million per year. Demand response for 600 MW would add an
27329 additional \$20 million⁷² per year (2019 dollars).⁷³

27330 **Lower Snake River Full Replacement (Used in Rate Sensitivity Analysis)**

27331 As discussed above, analytical and timing constraints prevented the base case analysis from
27332 incorporating a comprehensive zero-carbon replacement portfolio for the attributes of the
27333 lower Snake River projects under MO3. The need for that portfolio will likely increase as
27334 existing coal resources retire, and state policies prevent or deter the construction of additional
27335 dispatchable thermal resources (such as natural gas). This section explores the attributes, size,
27336 and costs of an expanded zero-carbon portfolio designed to replace the flexibility and capability
27337 of the lower Snake River projects. This analysis is not exhaustive and does not detail all costs
27338 estimates of replacing the lower Snake River projects. Instead, it outlines potential resource
27339 portfolio options and provides general estimates of costs for these portfolios. The analysis in

⁷¹ The presentation relied on can be found at: https://www.nwcouncil.org/sites/default/files/2019_1015_p4.pdf.

⁷² 600 MW Demand Response costs in zero-carbon scenarios; \$20 million for Bonneville finances, and \$30 million for region finances)

⁷³ Each of the capital costs above assumes that Bonneville finances the resources. In the other financing scenario, where regional public utilities would finance these resources, the costs would be marginally lower. The Socioeconomic analysis near the end of Section 3.4.3.5 examines various options for financing.

27340 this section produces a range of costs that is used in the power rates analysis as a “rate
27341 sensitivity.”

27342 The lower Snake River projects have operational attributes that make them uniquely positioned
27343 to maintaining the electrical reliability and stability of the regional transmission system.
27344 Replacing the lower Snake River projects with resources of equivalent abilities requires an
27345 understanding of the various attributes, services, and benefits that the lower Snake River
27346 projects provide today. A brief description of some of these attributes is provided below.

27347 • **Carbon Free:** The lower Snake River projects produce electric generation from water and
27348 are carbon free. A carbon free portfolio would include wind and solar resources,
27349 geothermal, nuclear small modular reactors (SMR), and storage technologies, such as pump
27350 storage and batteries (assuming they are charged with a carbon free generation source).

27351 • **Low Cost:** The lower Snake River projects are some of the lowest cost dams of the FCRPS.
27352 Table 3-112 summarizes the average cost of generation at the projects.

27353 • **Energy:** The lower Snake River projects produce on average around 1,000 megawatts of
27354 energy, which is roughly the amount of power it takes to power Seattle City Light’s load.
27355 While there is variability in streamflow over a typical year, there is also a certain amount of
27356 energy that has a high probability of occurring and can be counted on from year to year. To
27357 provide replacement energy, the following are resource options: combined-cycle natural
27358 gas plants, wind, solar, nuclear SMRs, and geothermal.

27359 • **Operating Reserves:** Bonneville uses the lower Snake River projects to provide balancing
27360 and contingency reserves. The lower Snake River projects are a part of the so-called ‘big ten
27361 projects’ within the FCRPS and are connected to automatic generation control allowing the
27362 lower Snake River projects to respond quickly to requested changes. The amount of actual
27363 reserves that Bonneville holds at the lower Snake River projects can change by project and
27364 by season due to such things as outages and water conditions. For planning purposes, 250
27365 MW of operating reserves are assigned to the lower Snake River projects. To replace these
27366 characteristics, the following types of resources and technologies are possibilities: simple-
27367 cycle natural gas plants such as an LMS100 or frame, reciprocating engine, pumped storage,
27368 batteries, and geothermal.

27369 • **Ramping Capability:** The lower Snake River projects have the unique ability during certain
27370 times of the year to back down their generation to very low levels at night and then
27371 increase (ramp) the generation during the day to meet daytime peaks. This ability may be
27372 less obvious when looking at only heavy load and light load hour generation. To assess the
27373 ability of the lower Snake River projects to ramp, Bonneville looked at actual generation to
27374 derive a sustained peak value (6 peak hours per weekday for a month). This value is
27375 representative of the average of the super-peak hours when the highest generation is
27376 needed. This super-peak value is used to represent what can be sustained over a period of
27377 time as opposed to a single hour of generation. Once the super-peak value was derived
27378 from historic generation, it was then compared to the minimum generation required of
27379 those projects, to derive how much the dams can ramp from minimum generation to a

27380 sustained peak. Depending on the time of the year, this can be over 2,000 MW. Also of
 27381 significant importance is the ramping speed of hydro resources like the lower Snake River
 27382 projects, which can change their output by hundreds of megawatts in just a few minutes.
 27383 Resource and technology options that provide this type of firm ramping capability include
 27384 the following: simple-cycle natural gas plants such as an LMS100 or frame, reciprocating
 27385 engines, pumped storage, and batteries. Table 3-160 presents the historical ramps for the
 27386 lower Snake River projects.

27387 **Table 3-160. Historical Sustained Ramping Capability (aMW) for the Lower Snake River**
 27388 **Projects**

Month	aMW
October	854
November	1,246
December	1,491
January	1,699
February	2,287
March	2,175
April I	1,957
April II	1,988
May	2,050
June	2,041
July	1,271
August I	426
August II	183
September	819

27389 **Replacement Resource Options**

27390 This section provides an overview of the known major categories of resources with attributes
 27391 that could be used in a portfolio designed to replace the capability of the lower Snake River
 27392 projects. The characteristics, benefits, and limitations of these resources are also discussed.
 27393 As discussed below, no one group or grouping of resources completely replaces the capabilities
 27394 of the lower Snake River projects. Further, many of the resources considered in this analysis
 27395 would need to be developed in sizes above known and tested utility-scale quantities. As such,
 27396 developing a portfolio with attributes that could fully replace the lower Snake River projects
 27397 would require additional considerations and analysis not addressed in the other MOs.

27398 ***Solar, Wind, and Batteries***

27399 Combining utility-scale solar, and wind resources with battery technology is one potential
 27400 resource replacement portfolio that could form an integral part of a comprehensive zero-
 27401 carbon replacement portfolio. Like the lower Snake River projects, this portfolios is carbon-free.
 27402 Wind and solar together provide a robust portfolio of zero-carbon energy. Solar, especially
 27403 during the summer, can provide energy during heavy load hours that follow the general load

27404 profile. Solar, however, does not produce energy during the night. Wind, however, can produce
27405 energy during both the daytime and nighttime hours. Together, these resources would allow
27406 for generation day and night, mitigating the lost firm energy production of the lower Snake
27407 River projects. Utility-scale batteries would replace the lost flexibility and ramping capability of
27408 the lower Snake River projects. However, the batteries provide an imperfect replacement for
27409 the lost capability of the lower Snake River projects because, while batteries can be discharged
27410 to provide energy, they also need to be recharged and consume energy on a net basis.

27411 The amount of megawatts needed from the solar, wind, and battery technology zero-carbon
27412 portfolio would be significantly above the lost generation from the lower Snake River projects.
27413 The annual average output of the lower Snake River projects is approximately 1,000 aMW.
27414 On average, the capacity factor for solar is 25 percent and for wind is 32 percent. Thus, for
27415 every 100 aMW of installed solar, only around 25 aMW of energy would be produced in an
27416 average year. Replacing 1,000 aMW of generation from the lower Snake River projects would
27417 take at a minimum 2,536 MW of solar capacity and 1,144 MW of wind capacity. These values do
27418 not take into account seasonality. The amount of wind reflects the amount that would be
27419 needed to equal the light load hour generation levels of the lower Snake River projects.
27420 The solar capacity amount reflects the amount needed to meet the average lower Snake River
27421 generation level in the remaining hours. It is assumed that there would be surplus energy at
27422 times from the wind and solar that could be used to recharge the batteries so they could be
27423 used for providing ramping and reserves.

27424 To provide a similar level of sustained ramping (Table 3-160, above) as the lower Snake River
27425 projects, 2,265 MW of batteries would be needed. Additionally, the lower Snake River projects
27426 provide 250 MW of operating reserves. This would bring the total to 2,515 MW of batteries
27427 needed to replicate the peaking and flexibility of the lower Snake River projects. Developing
27428 utility-scale batteries of this size is untested. The largest battery facility in the world is currently
27429 100 MW. The annual cost breakdown for this portfolio is described in Table 3-161.

27430 **Table 3-161. Summary Annual Fixed Cost Table for Zero-Carbon Portfolio**

Resource	Economic Life (year)	Annual Fixed Costs (\$)
Solar	30 year	\$282,000,000
Wind	25 year	\$178,000,000
Batteries	15 year	\$395,000,000
Total Annual Costs		\$855,000,000

27431 The values stated above are the estimated minimum amounts of installed solar and wind
27432 needed to ensure production of sufficient surplus to recharge the batteries. This assumption is
27433 untested and additional modeling would need to occur to verify its accuracy. If an additional
27434 770 MW of solar were needed to recharge the batteries to ensure a high probability of reserve
27435 power availability, then an additional \$111,000,000 of annual costs would be needed.
27436 Table 3-162 summarizes the replacement portfolio, including the additional solar, to replace
27437 most of the lost generation from the lower Snake River projects attributed from MO3.

27438 **Table 3-162. Potential Portfolio of Replacement Resources with Increased Solar**

Resource Type	Installed Capacity (MW)	Costs (\$)
Solar	3,306 MW	\$394,000,000
Wind	1,144 MW	\$178,000,000
Battery Storage	2,515 MW	\$395,000,000
Total	6,965 MW	\$966,000,000

27439 Another limitation of the wind, solar, and battery portfolio is its inability to provide voltage and
 27440 inertia⁷⁴ benefits. As described above, the lower Snake River projects provide voltage and
 27441 inertia benefits to the transmission system. Currently, wind, solar, and batteries do not provide
 27442 the same level of voltage support as an installed generator, though this may change with
 27443 advancements in technology. Providing inertia benefits from solar and wind resources and
 27444 battery technology, however, would be more challenging because these facilities do not have
 27445 the same heavy rotating mass as hydro generators. New technologies that would allow wind,
 27446 solar, and batteries to mimic the inertia characteristics of synchronous generators have yet to
 27447 be developed.

27448 ***Pump Storage***

27449 Pump storage is another carbon-free source of battery storage that could supply flexibility,
 27450 ramping, and reserves. Bonneville used the most recent reference plant from the NW Council
 27451 as a rough estimate for use of a pump-storage resource. For a 2,515 MW pump-storage plant,
 27452 the annual costs would be \$305 million. This presumes that a location could be found that
 27453 would support such a large volume of pumped storage and that the cost of pump storage is
 27454 scalable. The actual cost associated with pumped storage is very site- and water-dependent.
 27455 Further, such large amounts of pumped storage development would have environmental
 27456 implications as well as potential impacts to cultural resources, especially archaeological
 27457 resources and traditional cultural properties. The annual costs for pumped storage can appear
 27458 low as the costs are spread over a 50-year economic life. Additionally, pumped storage would
 27459 need an energy resource to replace the energy generation of the lower Snake River projects as
 27460 pumped storage plants consume energy while their ponds are being filled and are, therefore, a
 27461 net consumer of energy.

27462 ***Small Nuclear Reactor***

27463 SMRs (new generation nuclear reactors) are another carbon-free resource option for energy
 27464 that could potentially provide energy, some flexibility, and firm capacity. Cost estimates were
 27465 provided by UAMPS based on the Carbon-Free Power Project. Although the resource has not
 27466 been fully developed, preliminary estimates for a 654 MW unit put the cost of the SMR at
 27467 around \$151 million (2019 dollars) annually. Scaling the size up to the annual generation levels
 27468 of the lower Snake River projects would put the costs at roughly \$231 million (2019 dollars)
 27469 annually. The economic life assumed for SMR is 40 years. It is unknown if an SMR would be able

⁷⁴ Hydro, coal, gas, and nuclear generation all provide rotating inertia and voltage control capability that contribute to the stability of the transmission system.

27470 to provide ramping capability similar to the lower Snake River projects at this time. If they are
27471 not, then ramping capability from another technology (such as batteries) may also be needed.

27472 **Value of Lower Snake River Dam Flexibility**

27473 Bonneville uses the LSR projects to provide generation balancing reserves. The LSR projects are
27474 among the big ten projects and are connected to automatic generation control (AGC) which
27475 allows them to respond quickly to requested changes. The amount of generation balancing
27476 reserves that Bonneville holds at the LSR projects changes by project and by season. To
27477 estimate the value of flexibility provided by the LSR projects, Bonneville used rate case values
27478 from the BP-20 rate case and parsing out the values based upon how many reserves are held at
27479 the LSR projects. Table 3-163 summarizes the results.

27480 **Table 3-163. Estimates of Generation Input Revenue for Lower Snake River Dams**

Reserves	Value (\$)
Balancing INC Value	~ \$13,400,000
Balancing DEC Value	~ \$560,000
Operating Reserves	~ \$1,700,000
Total Gen Inputs Revenue	~ \$15,660,000

27481 **Value of Lower Snake River Dam Ramping Capability**

27482 The LSR projects can be uniquely operated during certain times of the year to help maintain
27483 system reliability by having their generation backed down to very low, or even zero generation
27484 levels at night when demand is low, and then ramped up during the day to meet daytime peaks.
27485 This ability may be less obvious when looking at only Heavy Load and Light Load Hour
27486 generation. To assess the value associated with ramping, Bonneville looked back at actual
27487 generation to derive a sustained peak value (6 peak hours per weekday). This value is
27488 representative of the average of the super peak hours when the highest generation is needed.
27489 This super peak value is used to represent the sustained peak generation over an extended
27490 period of a few hours. Once the super peak value was derived from historic actual generation, it
27491 was then compared to the minimum generation required of those projects, to derive how much
27492 the LSR can ramp from minimum generation to a sustained peak. To derive the value associated
27493 with this ramping, Bonneville calculated, the difference between graveyard prices and super
27494 peak prices using information from the BP-20 rate case studies and the 2030 LT Forecast
27495 models from Aurora. These prices in combination with the ramping amount combine to derive
27496 a value. Table 3-164 below summarizes the results.

27497 **Table 3-164. Value of Sustained Ramping Capability**

Month	MW	BP-20 Rate Case	2030 LT Forecast
October	854	\$168,000	\$1,053,000
November	1,246	\$216,000	\$1,613,000
December	1,491	\$248,000	\$1,485,000
January	1,699	\$280,000	\$1,449,000

Month	MW	BP-20 Rate Case	2030 LT Forecast
February	2,287	\$400,000	\$2,795,000
March	2,175	\$249,000	\$3,837,000
April I	1,957	\$232,000	\$2,074,000
April II	1,988	\$236,000	\$2,107,000
May	2,050	\$317,000	\$4,370,000
June	2,041	\$212,000	\$3,085,000
July	1,271	\$146,000	\$2,044,000
August I	426	\$31,000	\$268,000
August II	183	\$14,000	\$123,000
September	819	\$127,000	\$879,000
Total		\$2,876,000	\$27,180,000

27498 **Coal Retirement Considerations**

27499 The base case analysis described above assumed that current existing levels of coal would
 27500 remain in service to achieve the No Action Alternative level of LOLP of 6.6 percent. Under
 27501 future conditions with limited or no coal generation capacity, restoring LOLP to 6.6 percent—
 27502 the No Action Alternative LOLP level—requires a substantially larger portfolio of new resources.
 27503 To meet that level, an additional 1,350 MW to 4,150 MW of zero-carbon replacement resources
 27504 would be needed above and beyond the zero-carbon resources Bonneville (or the region)
 27505 procured to return the region to the No Action Alternative LOLP of 6.6 under MO3 in the base
 27506 case. Table 3-165 summarizes these values.

27507 As previously described, the urgency of regional resource adequacy was made clear in in the
 27508 2019 E3 report. In light of this context, eliminating generation of the lower Snake River projects
 27509 would exacerbate the existing resource adequacy issue by retiring significantly more generation
 27510 from the system at the same time that the region is struggling to replace coal generation
 27511 already scheduled for retirement.

27512

27513 **Table 3-165. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 3 Relative to the No**
27514 **Action Alternative**

Alternative	Base Case Coal Capacity Assumption in EIS (4,246 MW)			More Limited Coal Capacity (1,741 MW)			No Coal Capacity (0 MW)		
	Pre- Resource Build LOLP	Zero- Carbon Resource Build (MW)	Resource Build Relative to No Action (MW)	Pre- Resource Build LOLP	Zero- Carbon Resource Build (MW)	Incremental Resource Build for MO3 as Impacted by Additional Coal Retirement (MW)	Pre- Resource Build LOLP	Zero- Carbon Resource Build (MW)	Incremental Resource Build for MO3 as Impacted by Additional Coal Retirement(MW)
No Action	6.6%	0	0	27%	8,800	0	63%	28,000	0
MO3	14%	2,850	2,850	43%	13,000	1,350	79%	35,000	4,150

27515 Note: The replacement resources for the No Action Alternative include demand-response, wind, and solar; for MO3, the analysis additionally includes storage
27516 technology (e.g., batteries, pumped storage). The incremental resource builds under the more limited coal capacity or no coal capacity are additive with the
27517 resource builds under the base case.

27518 **Related Studies**

27519 In March 2018, the NW Energy Coalition (NWECC) released a report prepared by Energy
27520 Strategies Inc. that evaluated the effects of replacing the LSR projects' output using a
27521 combination of demand response, conservation measures, utility-scale solar and wind
27522 generation, and natural gas. The basic approach of this study was similar to that of the EIS for
27523 identifying both a potential least-cost and a potential zero-carbon portfolio for replacing lost
27524 hydropower. The NWECC study results were considered in testing the outputs of the EIS analysis.
27525 Compared to the CRSO EIS, the scope of the NWECC study is much narrower, making direct
27526 comparisons to the CRSO EIS difficult. The study uses older load data and natural gas price
27527 forecasts, has lower estimates for transmission-related costs, and therefore underestimates
27528 impacts to Bonneville ratepayers. Appendix H compares the NWECC report and the EIS analysis
27529 in more detail.

27530 In July 2019, ECONorthwest published a report commissioned by Vulcan, Inc. that adopted
27531 NWECC's 2018 power replacement study in an effort to examine various tradeoffs associated
27532 with dam removal on the lower Snake River. Compared to the findings in the CRSO EIS, the
27533 most significant difference associated with the Vulcan study stems from the inclusion of
27534 quantified "non-use" values associated with the Columbia River and differences in cost
27535 estimates associated with irrigation system modifications. Similar to the NWECC study,
27536 transmission-related costs appear to be considerably underestimated.

27537 In December 2019, Northwest River Partners released a report prepared by EnergyGPS
27538 Consulting, LLC (EGPSC), reviewing the above NWECC study. The review points out that the
27539 NWECC study relied on load and resource forecasts are now over 3 years old. In large part due to
27540 changing regional energy and climate policies, many more coal-plants are slated for retirement
27541 since the NWECC study, and EnergyGPS expects that all cost-effective demand response and
27542 energy efficiency resources will be used to replace the lost coal generation rather than being
27543 available to replace lost hydropower. Further, the reliance on imports was noted as being too
27544 high, the cost of transmission too low, and no penalty associated with increasing reliance on
27545 fossil-fuel-based generation. The EnergyGPS study used updated load, resource, and policy
27546 information to propose a replacement portfolio for the LSR generation using new renewable
27547 resources with battery storage, an adder for transmission costs to integrate the new resources,
27548 and an adder for the compliance cost of incremental carbon emissions. This portfolio would
27549 cost about \$860 million per year or \$96/MWh. This cost estimate is in line with the costs
27550 identified in the EIS analysis.

27551 **BONNEVILLE'S FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION**
27552 **PLAN COSTS**

27553 The summary rate table for MO3 includes an estimate of \$281 million in annual costs (adjusted
27554 to 2019 dollars) for the Bonneville Fish and Wildlife Program in the Base Case analysis, which is
27555 consistent with the No Action Alternative, but excludes the LSRCP. Upon the breaching of the
27556 lower Snake River projects, Bonneville would no longer have an obligation to fund the

27557 operations and maintenance of the LSRCP, estimated at \$34 million annually when adjusted for
27558 2019 dollars, because Bonneville's funding authority is directly tied to the operation of the
27559 lower Snake River projects. In so stating, Bonneville also recognizes that there will be
27560 transitional needs that would have to be addressed by Bonneville and other funding sources.

27561 As previously discussed, Bonneville Fish and Wildlife Program funding decisions are not being
27562 made through the CRSO EIS. However, Bonneville Fish and Wildlife Program costs are included
27563 in the EIS to inform a transparent cost analysis for each MO, as discussed in Section 3.19. Future
27564 budget adjustments will be made in consultation with the region through Bonneville's budget-
27565 making processes and other appropriate forums and consistent with existing agreements. In the
27566 case of MO3, Bonneville included a range of potential Bonneville Fish and Wildlife Program
27567 costs to acknowledge the possibility that MO3 could provide biological benefits to fish and
27568 wildlife and that this could, in turn, reduce the need for some offsite mitigation funded by the
27569 Bonneville Fish and Wildlife Program. Not including this potential scenario could impact the
27570 analysis of the overall costs for MO3, potentially showing higher cost than would ultimately be
27571 required. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related
27572 to managing its Fish and Wildlife program and also acknowledges the uncertainty around both
27573 the magnitude of biological benefits and the potential impacts on funding, including the timing
27574 of funding decisions. For this reason, potential adjustments to the Bonneville Fish and Wildlife
27575 Program, which are estimated to range up to \$105 million, are analyzed as part of the Rate
27576 Sensitivity analysis.

27577 **EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE**

27578 **Bonneville Interconnections**

27579 The developers of individual replacement generation resources would have to construct certain
27580 transmission facilities (e.g., lines and equipment) to interconnect the resource to the
27581 transmission system. Those facilities would result in additional costs, which would vary
27582 depending on the location of the resource with respect to the transmission network, size of the
27583 individual project, and other factors.

27584 Bonneville, for its part of the resource interconnection, would also have to construct additional
27585 transmission facilities at the point of interconnection in order to interconnect the new resource
27586 to the transmission system. The Bonneville portion of the interconnection would require
27587 equipment such as bulk transformers, circuit breakers, and other substation equipment, which
27588 may require the expansion of multiple existing substations. The addition of transmission
27589 substation infrastructure to accommodate interconnections can take several years to plan,
27590 permit, and construct, especially at those substations requiring expansion beyond the current
27591 footprint.

27592 Based on the assumptions described above, Bonneville identified approximately \$72 million in
27593 direct costs on the transmission network (which the customer would fund and Bonneville would
27594 repay in transmission credits) necessary to accommodate the interconnections for the least-
27595 cost portfolio under MO3. Bonneville identified \$150 million in direct costs on the transmission

27596 network necessary to accommodate the interconnection for the zero-carbon portfolio under
27597 MO3. These would cost \$9.1 million to \$13 million when annualized. The costs identified here
27598 include land and substation equipment.

27599 As discussed above under *Lower Snake River Replacement* in this section, a replacement
27600 portfolio containing a mix of batteries and wind generation could replace the attributes of the
27601 lower Snake River projects that would be breached under MO3. Depending upon the location
27602 of the wind generation and battery placement, additional direct network interconnection costs
27603 would be required.

27604 **Bonneville Transmission System Reliability and Operations**

27605 Under MO3, assuming replacement resources under either of the two replacement resource
27606 portfolios are online by the time the changes in hydropower generation are implemented, it is
27607 unlikely that any additional transmission reinforcements beyond those described below are
27608 necessary. However, the timing of bringing replacement resources online may affect the timing
27609 of the existing transmission reinforcements that have been identified.

27610 Prior to evaluating the effects of a potential breach of Ice Harbor Dam under MO3, Bonneville
27611 had identified the need for a transmission reinforcement project just beyond the 10-year
27612 planning horizon to maintain reliable load service to the Tri-Cities area and to support
27613 transmission system reliability. The base need for the project would arise independent of
27614 removal of the generation at Ice Harbor. The timing of the reinforcement, however, is very
27615 dependent upon when Ice Harbor generation might be removed. The generation at Ice Harbor
27616 is embedded, or co-located, with the loads in the Tri-Cities, making it a critical source of power
27617 to serve the Tri-Cities area load, particularly during peak summer load conditions. Due to
27618 current limits on transmission infrastructure into the Tri-Cities area, an outage of one of the
27619 transmission lines connecting the Tri-Cities area to the main transmission grid substantially
27620 limits the amount of energy that can be delivered to the Tri-Cities load. During such outages,
27621 generation from Ice Harbor ensures reliable service to the Tri-Cities load. The generation at Ice
27622 Harbor also allows Bonneville to take lines out of service for planned maintenance and other
27623 operational reasons without affecting reliable service to the Tri-Cities area. The inability to take
27624 lines out of service for maintenance and to respond to operational constraints, such as the loss
27625 of a transmission line, could increase risk to transmission system reliability and result in loss of
27626 load to the Tri-Cities area.

27627 Under MO3, the loss of hydropower generation at Ice Harbor would require that the
27628 reinforcement project be in place prior to breaching of the dams, which may be sooner than
27629 would be required under the No Action Alternative. If the dams were breached prior to
27630 completion of the reinforcements, the Tri-Cities area would be vulnerable to the potential loss
27631 of load during congestion. The scope of the likely reinforcement would include a new
27632 substation, a new 20-mile-long transmission line, and the expansion of an existing substation
27633 near the Tri-Cities. The reinforcement project would cost approximately \$94 million in direct
27634 costs to construct. It should be noted that these types of transmission system reinforcements
27635 typically take many years to plan, permit, and construct. Any transmission reinforcement

27636 project would likely result in additional, but currently unknown, impacts to environmental and
27637 cultural resources, which may include vegetation, wildlife habitat, archeological resources, and
27638 traditional cultural properties. Additional environmental and cultural impacts from transmission
27639 reinforcement projects would be identified and analyzed by Bonneville during future site-
27640 specific environmental review, including NEPA and permitting processes.

27641 If the replacement resources assumed for MO3 were not in place when the changes in
27642 hydropower generation were implemented, there could be a period when the transmission
27643 system would need to operate at reduced operating limits in some locations until additional
27644 resources were brought online (or transmission infrastructure were constructed). In addition to
27645 the loss of hydropower from the Snake River projects, the reduction in hydropower at the
27646 lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville) in the summer
27647 months (except for August under this alternative) would likely result in fewer generators being
27648 online and available to maintain an acceptable voltage profile and provide dynamic support for
27649 the larger transmission system. If too few generators are online, the operating limits of the
27650 transmission system may need to be lowered to avoid equipment damage and potential
27651 uncontrolled load loss. Operating at lower operating limits could result in increased congestion
27652 and a re-deployment of resources throughout the Western Interconnection to meet the
27653 required load demands at that time. This congestion goes beyond the regional transmission
27654 congestion levels that are reported under the *Regional Transmission System Congestion Effects*
27655 section below.

27656 Limitations around voltage and dynamic response would be aggravated under scenarios with
27657 reduced coal generation, as coal generation plants provide similar support to the system as
27658 hydropower generators. Renewable resources currently neither have the technology nor the
27659 requirement to provide comparable dynamic and frequency support. Technology under
27660 development and implementation of additional requirements may be needed under a zero-
27661 carbon resource portfolio in order to have certainty that replacement solar resources will be
27662 able to provide adequate reactive and dynamic support to respond to larger transmission
27663 disturbances. Again, it can take several years to plan, permit, and construct these transmission
27664 reinforcements should they be needed.

27665 If a renewable resource and battery technology replacement portfolio is used, the location of
27666 the batteries provides different benefits. If batteries are co-located with new or existing
27667 renewable resource interconnections, the ability of the resource to provide energy, with
27668 certainty, at peak load would increase. Other concerns would still need to be addressed, such
27669 as what transmission and resource(s) arrangements to provide battery charging when
27670 generation from the solar or wind resource is unable to do so. Generation from the FCRPS
27671 hydro projects could provide alternative charging, which would help shape FCRPS generation
27672 (incremental storage to the remaining CRSO projects).

27673 Batteries sited at the current transmission stations interconnecting the lower Snake River
27674 projects could reduce interconnection facilities and costs required to accommodate the
27675 batteries under this resource replacement portfolio. However, there may be limitations at

27676 existing transmission substations preventing expansion to accommodate the interconnection of
27677 battery storage capacity. There is some concern that the capacity at interconnection facilities
27678 may still be “consumed” if synchronous condensing capability is used at the powerhouses of
27679 the lower Snake River projects.

27680 If the batteries were sited at load centers, there could be a transmission system reliability
27681 benefit. In particular, it would be very desirable to have some batteries located within the Tri-
27682 Cities load area, as it would eliminate or delay the difficulties with the timing of the
27683 transmission reinforcements identified above.

27684 In other major load centers such as Portland and Seattle, the addition of batteries could
27685 substantially reduce transmission loading under peak conditions, providing additional benefits
27686 to the transmission system.

27687 **Regional Transmission System Congestion Effects**

27688 The fluctuation in the number of congestion hours caused by MO3 for either replacement
27689 resource portfolio relative to the No Action Alternative would be small in comparison to the
27690 fluctuations in congested hours caused by variations between runoff conditions
27691 (i.e., differences between high, median, and low runoff conditions).

27692 For the majority of transmission paths, for both replacement resource portfolios in low runoff
27693 conditions, congested hours would have little to no change (less than 30 hours) under MO3
27694 compared to the No Action Alternative.

27695 In both median and high water runoff conditions, some north-to-south transmission paths
27696 would experience a slightly increased number of congested hours compared to the No Action
27697 Alternative. The Pacific DC Intertie has the greatest increase in congestion hours of the north-
27698 to-south paths, increasing congestion by over 365 additional hours compared to the No Action
27699 Alternative during high water runoff years as more power is exported out of the region. During
27700 these times of increased congestion, the amount of additional power that could be exported
27701 outside of the Northwest via the Pacific DC Intertie to meet power needs could be limited by
27702 the congestion.

27703 With less hydropower generation (particularly without the lower Snake River CRS projects)
27704 under MO3, however, the west-to-east lines, including those that are the most congested
27705 under the No Action Alternative, would experience fewer congested hours under high runoff
27706 conditions. The greatest decrease would be along the Hemingway to Summer Lake transmissison
27707 path, as less hydropower generation would be available to be sent east. The Hemingway to
27708 Summer Lake transmission path could have a decrease in congestion by about 150 and
27709 498 hours, depending on replacement resource portfolio, during a high water runoff year.

27710 Overall, changes in the patterns of CRS generation under MO3 would have a relatively small or
27711 minor impact on congestion for most Pacific Northwest transmission paths and a minor to
27712 moderate increase in congestion hours for some north-to-south paths, particularly the Pacific

27713 DC Intertie during median and high runoff conditions. There would be a minor to moderate
27714 improvement in congestion hours on some west-to-east lines, particularly the Hemingway to
27715 Summer Lake transmission path.

27716 If the assumed replacement resources are not in place when the changes in hydropower
27717 generation and breach of the lower Snake River projects are implemented under this
27718 alternative, the number of hours and location of congestion would change depending on which
27719 replacement resources were online at the time.

27720 Under a renewable resource and battery technology replacement portfolio, transmission
27721 congestion patterns could shift depending upon the location of the wind generation and
27722 battery placement.

27723 Under a limited to no coal future, if a net reduction in resource availability also occurred in the
27724 Pacific Northwest or other regions or both due to additional coal retirements, then the effects
27725 of CRS hydropower reductions with or without replacement resources could shift from what is
27726 reported above.

27727 Detailed graphs depicting the number of hours of congestion along the individual flow paths
27728 under different water years appear in Appendix H.

27729 **ELECTRICITY RATE PRESSURE**

27730 **Bonneville Wholesale Power Rates**

27731 Under MO3, there would be upward wholesale power rate pressure for all portfolios due to the
27732 large decrease in hydropower generation. The highest upward rate pressure would occur under
27733 the zero-carbon portfolio that would result in the highest average wholesale rates in the
27734 Bonneville-financed replacement resources portfolio.⁷⁵

27735 **Bonneville Finances**

27736 Table 3-166 presents the estimated rate pressure effects on Bonneville's wholesale power rate
27737 under MO3 based on changes in the amount of hydropower generated and the secondary
27738 (market) sales. In MO3, Bonneville would realize some cost savings related to the cost of
27739 operations and maintenance at the lower Snake River projects. The annualized cost of
27740 structural measures associated with MO3 would total \$17 million (2019 dollars), but this is
27741 offset by \$7 million in reduced capital expenses for the breached dams, in addition to the
27742 \$47 million decrease in annual operation and maintenance expenditures (2019 dollars).

⁷⁵ An important assumption in the MO3 rate analysis is that the Bonneville would not pay for the cost of dam breaching. Rather, for this EIS, it is assumed that the cost of dam breaching would be covered by congressional appropriations. The cost to decommission and breach the LSR projects is estimated at \$994 million and includes development of infrastructure to facilitate drawdown of the reservoirs, breach of the reservoirs, and diversion of the river, as well as a contingency of 50 percent. If Bonneville were to recover these costs, the rate effects discussed below would be substantially higher.

27743 Together with the \$34 million in lower F&W Program expenses, net cost savings is \$71 million
27744 per year in 2019 dollars. However, these savings are more than offset by cost pressures
27745 associated with replacement resource builds and effects on the power market and secondary
27746 revenues. Should the upward rate pressure lead to rate increases (i.e., assuming Bonneville or
27747 other entities were unable to balance the additional costs), Bonneville wholesale power rates
27748 could range from \$3.31 per MWh to \$6.67 per MWh (2019 dollars) higher depending on the
27749 replacement portfolio (e.g., least-cost or zero-carbon) and financing portfolio (e.g., Bonneville-
27750 or region-financed). This represents an upward rate pressure between 9.6 and 19.3 percent in
27751 the average Bonneville wholesale power rate compared to the No Action Alternative.

27752 In the scenarios with limited or no coal generation in the region, these upward rate pressures
27753 would likely be substantially higher. Appendix H, *Power and Transmission*, presents a full
27754 breakdown of sensitivity of results to coal-closure scenarios and structural measure costs as
27755 well as the potential effects on wholesale power rates.

27756 Summary results for Bonneville's wholesale power rate pressure analysis in the Bonneville
27757 Finances scenario are presented in the first section of Table 3-166. As discussed in Section
27758 3.7.3.1, the second section of Table 3-166 provides the cost pressure to the region of MO3 in
27759 light of potential carbon compliance and accelerated coal retirements.

27760 Results for the Region Finances scenario are presented in Table 3-167. It is important to note
27761 that the wholesale power rates presented in this table are from the perspective of Bonneville's
27762 wholesale power rate. In the Region Finances scenario, replacement resource costs are
27763 assumed to be recovered by regional utilities (not Bonneville), and therefore, are excluded from
27764 Bonneville's power rates. The socioeconomic chapter shows the geographic distribution of rate
27765 impacts down to retail rates in both scenarios. As such, the costs which are missing from
27766 Bonneville rates in the Region Finances scenario in this section are included in the retail rate
27767 impacts of the consortium of public customers assumed to finance the resource replacement.
27768 The summary analysis focuses on the Bonneville Finances scenario, because this includes most
27769 of the relevant costs affecting its customer base, while the Region Finances scenario excludes
27770 real costs affecting regional rates which are not explicitly included in Bonneville's wholesale
27771 power rate.

27772 **Bonneville Finances**

27773 **Table 3-166. Average Bonneville Wholesale Power Rate (\$/MWh) under Multiple Objective 3,**
27774 **for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures**
27775 **Associated with Additional Sensitivity Analysis**

Change in Bonneville's Priority Firm Rate, Bonneville Finances					
		Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
		\$ rate pressure	change from NAA	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)					
1	Base Rate	\$41.23 /MWh	\$6.67 /MWh	\$37.88 /MWh	\$3.31 /MWh
2	Change from NAA due to Costs	\$381	18.6%	\$199	9.6%
3	Change from NAA due to Load		0.7%		-0.1%
4	Total Base Change in Rate		19.3%		9.6%
Rate Sensitivities (annual cost in \$ millions)					
5	Fish and Wildlife Costs	-\$105 to \$0	-5.1% to 0%	-\$105 to \$0	-5.1% to 0%
6	Integration Services	\$0 to \$527	0% to 23.9%	-\$5 to -\$5	-0.2% to -0.2%
7	Resource Financing Assumptions	\$0 to \$90	0% to 4.1%	\$0 to \$24	0% to 1.1%
8	Resource Cost Uncertainties	\$0 to \$12	0% to 0.6%	\$0 to \$7	0% to 0.3%
9	Demand Response	-\$12 to \$52	-0.5% to 2.4%		
10	Oversupply	-\$1 to \$0	0% to 0%	-\$5 to -\$3	-0.2% to -0.1%
11	Total Rate Sensitivities	-\$118 to \$681	-5.6% to 31.0%	-\$115 to \$23	-5.5% to 1.1%
12	Total Base Effect + Sensitivities	\$263 to \$1,062	13.7% to 50.3%	\$84 to \$222	4.1% to 10.7%
Other Regional Cost Pressure (annual cost in \$ millions)					
		Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
		\$ pressure	change from NAA	\$ pressure	change from NAA
13	Regional Cost of Carbon Compliance	\$34 to \$168		\$109 to \$623	
14	Regional Coal Retirements (capital)	\$82 to \$371			
15	Regional Coal Retirements (other)	too uncertain to estimate		too uncertain to estimate	

27776 Note: Line 14 represent the approximate range in fixed costs for replacement resources for the more limited coal
27777 scenario and the no coal scenario. Additional changes in value, denoted by line 15, would occur from changes in
27778 market prices, changes in technology, and many other factors. Because the retirement of coal plants in the region
27779 will change the utility landscape far from the current condition, there is not enough information available to
27780 extrapolate from today's information. Base rate includes Colville settlement payment, which has a 2 to 5 percent
27781 increase from the No Action Alternative.
27782

27783 **Base Case Analysis**

27784 Base rate pressures range from 9.6 percent to 19.3 percent depending on the resource
27785 portfolio, with a higher rate pressure associated with the zero-carbon resource replacement.
27786 In the zero-carbon scenario, annual average cost pressure is \$381 million per year (2019
27787 dollars), equate to a 18.6 percent upward pressure, and a small decrease in preference
27788 customer loads leading to a 0.7 percent upward pressure on power rates, resulting in an overall

27789 upward rate pressures of 19.3percent. Rate pressure includes a reduction in O&M expenses for
27790 lower Snake River projects and cost savings associated with the LSRCP, which are more than
27791 offset by large capital costs to finance and maintain the solar resource replacement, structural
27792 measure debt financing, lower net secondary sales revenues, and higher energy efficiency
27793 expenses associated with the demand response program. In the conventional least-cost
27794 scenario, the \$199 million in upward rate pressure, which results in an upward rate pressure of
27795 9.6percent, is associated with a reduction in O&M expenses for lower Snake River projects and
27796 cost savings associated with the LSRCP, which are more than offset by large capital costs to
27797 finance and maintain the gas turbine resource replacement, structural measure debt financing,
27798 and lower net secondary sales revenues. In addition to these cost pressures, loads in the least-
27799 cost scenario are virtually flat compared to the No Action Alternative, contributing to a 0.1
27800 percent downward pressure on power rates. Overall, the base rate pressure is 6.0 percent.

27801 Rate Sensitivity Analysis

27802 Rate sensitivities are presented in Table 3-166, lines 5 through 11 to provide quantitative
27803 estimates relative to the additional sensitivity analyses described in Section 3.7.3.1.

27804 Line 5 describes potential additional cost reductions to Bonneville’s Fish and Wildlife program
27805 that could be achieved above the reduction assumed in the base case rates analysis. These
27806 reductions reflect lower costs associated with fish and wildlife mitigation efforts due to a
27807 combination of the loss of the lower Snake River dams, higher spill requirements, and lower
27808 overall system generation. See Section 3.7.3.5 (“Bonneville’s Fish And Wildlife Program And
27809 Lower Snake River Compensation Plan Costs.”)

27810 The Integration Services sensitivity (line 6) under MO3 evaluates the cost of replacing the full
27811 capability of the lower Snake River projects. As described above, the base case rates analysis
27812 estimates the zero-carbon resource costs needed to return the region to the No Action
27813 Alternative LOLP level (2,550 MW of solar generation), along with returning a portion of the lost
27814 flexibility of the lower Snake River projects (1,275 MW of battery technology). The costs to fully
27815 replace the lower Snake River project capability with zero carbon resources is discussed in
27816 section 3.7.3.5 (“Lower Snake River Replacement (Used In Rate Sensitivity Analysis)”). The
27817 Integration Services sensitivity takes these cost estimates and applies them to the base case
27818 rates analysis.

27819 For the zero-carbon portfolio, the full capability replacement costs for the LSR is estimated to
27820 cost \$966 million per year, which results in a net incremental cost of \$527 million above the
27821 base case analysis.⁷⁶

27822 For the conventional least cost portfolio, no incremental replacement resources are needed
27823 because the resources assumed in this portfolio are dispatchable (*i.e.*, movable). This resource

⁷⁶ The \$527 million is calculated by subtracting the base case resource cost assumption of \$419 million from the full replacement cost portfolio of \$966 million described in Section 3.7.3.5 (“Replacement Resource Portfolios”). This difference, \$547 million, is then reduced by \$20 million for revenue associated with returned contingency and balancing capacity relative to the base case analysis.

27824 portfolio would also return some of the I Cost contingency and balancing reserves relative to
27825 the base rate analysis, restoring contingency and balancing revenues by \$5.3 million.

27826 Resource financing assumptions (line 7), which address alternative amortization periods to the
27827 30 years assumed in base rates, show upward cost pressure of \$90 million per year in the zero-
27828 carbon portfolio and \$24 million per year in the least-cost scenario.

27829 Resource cost uncertainties (line 8) could add up to \$12 million in additional cost pressure in
27830 the zero-carbon portfolio and add up to \$7 million in additional cost pressure in the least-cost
27831 portfolio.

27832 Demand response costs (line 9) could be lower than assumed in the \$20 million/year in base
27833 rates; a potential cost savings of \$12 million per year is shown on the low end for this
27834 sensitivity. However, to account for the challenges to scaling up demand response programs in
27835 Bonneville's service territory, this portion of the resource portfolio could be as high as \$52
27836 million per year higher than assumed in base rates if up to 50 percent of the program needed to
27837 be replaced with a 300MW solar and battery resource instead.

27838 OMP costs (line 10) associated with oversupply events could be \$1 million per year lower in the
27839 zero-carbon portfolio and up to \$5 million in the least-cost portfolio.

27840 For the integration services sensitivities under MO3, the values reflect a combination of the
27841 change to resource flexibility and reserve carrying capability. To value flexibility associated with
27842 the lower Snake River projects, the study incorporated two changes relative to the LOLP
27843 analysis in base rates: (1) the addition of batteries for storage tied to the 2,250 MW solar
27844 project, and (2) a reduction in generation inputs revenues of \$21 million as a proxy for the value
27845 of lost flexibility.⁷⁷

27846 The flexibility sensitivity incorporates first a lower replacement resource cost assumption for
27847 the zero-carbon resource portfolio. The least-cost portfolio LOLP studies showed that solar
27848 installations without accompanying batteries for storage would have \$300 million in annualized
27849 capital costs over 30 years, which does not value the unique flexibility and balancing
27850 characteristics of the lower Snake River projects. The portfolio selected for base rates added
27851 batteries to 50 percent of the installed capacity and includes these increased costs into the
27852 revenue requirement for a total annual cost of \$418 million. The difference between these two
27853 portfolios, establishes a lower bound for the zero-carbon portfolio with a reduction from base
27854 rates of a \$129 million.

27855 Because the solar installation without flexibility and storage is incomplete, additional valuation
27856 was necessary for this lower bound estimate. To monetize the value of changes in contingency
27857 and generation balancing reserve carrying capability, the sensitivity analysis includes (1) any
27858 changes to generation inputs sales, (2) integration costs associated with contingency and

⁷⁷ This estimate was calculated as the BP-20 embedded cost of reserves \$7.08/kW-mo applied to the aggregate reserve carrying capability of 250 MW for the lower Snake River projects.

27859 balancing needs of replacement resources, and (3) energy shaping benefits from ramping
27860 capability of the lower Snake River projects into super-peak periods.

27861 Generation inputs revenues in base rates were assumed to be \$21 million lower than the No
27862 Action Alternative. To fine-tune this proxy, the sensitivity analysis looked at the lower Snake
27863 River projects' contribution to reserves carried to provide contingency and balancing services.
27864 The lower Snake River projects hold about 20 percent of Bonneville's upward flexibility
27865 (increases), 8 percent of its downward flexibility (decreases), and about 5 percent of its
27866 operating reserves for the FCRPS.⁷⁸ The estimated value of the reserves held at the lower Snake
27867 River projects in the No Action Alternative is \$15.7 million using BP-20 rates. Therefore, the
27868 lower bound values include an assumed cost savings of \$5.3 million (\$15.7 million less
27869 \$21 million) for this incremental difference of assumed generation input revenue impacts.⁷⁹

27870 Annual resource integration costs associated with replacement resources under MO3 were
27871 calculated using BP-20 operating and generation balancing reserve rates. Estimated annual
27872 integration costs for the 2,250MW solar resource replacement under MO3 for the zero-carbon
27873 portfolio ranged from \$61.7 million to \$72.2 million, with the average \$66.9 million. This
27874 estimate reflects the intermittent characteristics of the carbon-free replacement which requires
27875 both contingency and generation balancing reserve services.

27876 The value of lost sustained ramping capability was based upon historical data. Actual
27877 generation shaping into the 6-hour super peak period on the lower Snake River projects
27878 informed the quantity of super-peak shaping which might reasonably be expected to continue
27879 absent breach of the dams. This super-peak quantity was then compared to the minimum
27880 generation required of those projects to derive how much the dams can ramp from minimum
27881 generation to a sustained peak. To derive the value associated with this ramping, the difference
27882 between graveyard prices and super-peak prices was used, which relied on BP-20 rate case
27883 studies to estimate a value range. This range is used as an incremental cost not included in base
27884 rates for this sensitivity of \$2.9 million to \$27.2 million, for an average ramping value of
27885 \$15.1 million. This ramping value is included in the lower-bound sensitivity.

27886 For a high-end sensitivity flexibility costs, Bonneville analyzed the cost of a like-for-like
27887 replacement of the lower Snake River projects. As detailed above, this included a combination
27888 of solar, batteries, and wind generation sized to reflect the reserves carrying capability of the
27889 system, as well as ramping and flexibility to move generation into higher-valued periods. This
27890 resulted in an annual average cost of \$966 million per year, which is \$548 million above the
27891 resource capital cost included in base rates. However, because this like-for-like resource
27892 portfolio builds comparable flexibility to the lower Snake River projects, the generation inputs

⁷⁸ In MO3, with the loss of the lower Snake River projects, the generation balancing reserves held by these projects was shifted to other generating facilities in the FCRPS, thereby reducing the capability of other FCRPS resources. The replacement of energy lost at these other facilities results in additional generation needs that must be met through the resource replacement portfolios.

⁷⁹ This lower bound reduction applies to both the zero-carbon and conventional portfolios.

27893 reduction of \$21 million is subtracted from the incremental resource cost to produce a high-
27894 end sensitivity of \$527 million.

27895 Line 6 in Table 3-166 includes the sum of (1) forecast differences in resource replacement costs,
27896 (2) forecast changes to generation inputs revenues, (3) forecast changes associated with
27897 integration costs, and (4) forecast changes associated with the incremental value of ramping
27898 capability to produce a range of \$-41.3 million to \$527 million for the zero-carbon portfolio, and
27899 \$-5.3 million for the conventional portfolio.⁸⁰

27900 Other Regional Cost Pressure

27901 Cost pressures to regional utilities, which do not necessarily impact Bonneville's wholesale
27902 power rates, but could in the future, are presented in lines 13 and 14. Effects associated with
27903 regional carbon compliance laws are unknown, pending current legislation in Oregon and
27904 Washington as discussed in Section 3.7.3.1. If binding estimates effective in the future are
27905 enforced to the resource portfolio in MO3, regional utilities could face cost pressure relative to
27906 the No Action Alternative of \$34 to 168 million per year. In the conventional least-cost scenario,
27907 carbon enforcement costs could range between \$109 and \$623 million per year.

27908 As described in Sections 3.8.3.1, Availability of Coal Resources subsection, and 3.8.3.2, Effects
27909 on Power System Reliability subsection, regional utilities would need to add 8,800 MW of
27910 additional zero-carbon resources in the limited coal capacity scenario and 28,000 MW of
27911 additional zero-carbon resources in the no coal scenario to maintain regional LOLP at No Action
27912 Alternative levels (6.6 percent). See Table 3-166. Lines 14 and 15 estimate the incremental
27913 zero-carbon resources costs needed by the region to maintain the No Action Alternative LOLP
27914 of at least 6.6 percent under MO3 in light of a limited or no coal assumption. An "incremental
27915 zero-carbon resource cost" occurs if the combination of (1) the resources Bonneville or the
27916 region is expected to acquire under the MO, plus (2) 8,800 MW (under the limited coal
27917 scenario) or 28,000 MW (under the no coal scenario), is less than the total amount of zero-
27918 carbon resources needed to return the region to the No Action Alternative LOLP of 6.6 percent.

27919 For the limited coal capacity scenario under MO3, a minimum of 13,000 MW of zero-carbon
27920 resources would need to be added to maintain regional LOLP at the No Action Alternative level
27921 of 6.6 percent. Bonneville or the region is expected to acquire 2,850 MW of zero-carbon
27922 resources under MO3 in the base case. Adding 2,850 MW to 8,800 MW is *less than* the
27923 minimum 13,000 MW. The region would need to acquire an additional 1,350 MW of zero-
27924 carbon resources to return regional LOLP to the No Action Alternative level of 6.6 percent.
27925 The incremental cost to the region of those additional resources is estimated to be \$82 million
27926 per year.

27927 For the no coal capacity scenario under MO3, a minimum of 35,000 MW of zero-carbon
27928 resources would be needed to maintain regional LOLP at the No Action Alternative level of

⁸⁰ The conventional least-cost portfolio replacement only incorporates the change to generation inputs revenues assumed.

27929 6.6 percent. Bonneville or the region is expected to acquire 2,850 MW of zero-carbon resources
27930 under MO4 in the base case. Adding 2,850 MW to 28,000 MW is *less than* the minimum
27931 35,000 MW. The region would need to acquire an additional 4,150 MW of zero-carbon
27932 resources to return regional LOLP to the No Action Alternative of 6.6 percent. The incremental
27933 cost to the region of acquiring those resources is estimated to be \$371 million a year.

27934 **Region Finances**

27935 Results for the region finances scenario are presented in Table 3-167. It is important to note the
27936 rate pressures in this table are from the perspective of Bonneville’s wholesale power rates.
27937 In the Region Finances scenario, replacement resource costs are excluded from Bonneville’s
27938 wholesale rate, with those costs collected from rates charged by other entities in the region.
27939 The costs of replacement resources would be ultimately paid by the customers of utilities that
27940 would be receiving less power from Bonneville. The Socioeconomic section below shows the
27941 geographic distribution of rate impacts down to retail rates in both scenarios, so that these
27942 costs which are not in Bonneville rates in the Region Finances scenario are included in retail
27943 rate impacts of the consortium of public customers assumed to finance the resource
27944 replacement.

27945 **Table 3-167. Average Bonneville Wholesale Power Rate (\$/MWh), for the Base Case without**
27946 **Additional Coal Plant Retirements as well as the Rate Pressures associated with Additional**
27947 **Sensitivity Analysis for the Case, Region Finances**

Change in Bonneville's Priority Firm Tier 1 Rate, Region Finances				
	Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
	\$ rate pressure	change from NAA	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)				
Base Rate	\$37.84 /MWh	\$3.28 /MWh	\$37.41 /MWh	\$2.85 /MWh
Change from NAA due to Costs	\$16	0.8%	-\$7	-0.4%
Change from NAA due to Load		8.7%		8.6%
Total Base Change in Rate		9.5%		8.2%

27948

27949 **Market Prices**

27950 Under MO3, average market prices would increase compared to the No Action Alternative.
27951 With the conventional least-cost portfolio, the expected average market price would be
27952 \$19.87 per MWh, an increase of \$0.45 per MWh or 2.3 percent compared to the No Action
27953 Alternative. With the zero-carbon portfolio, the expected average market price would be
27954 \$19.73 per MWh, an increase of \$0.32 per MWh or 1.6 percent compared to the No Action
27955 Alternative. Figure 3-185 shows the average market price and average CRS hydropower
27956 generation by month under the least-cost portfolio.

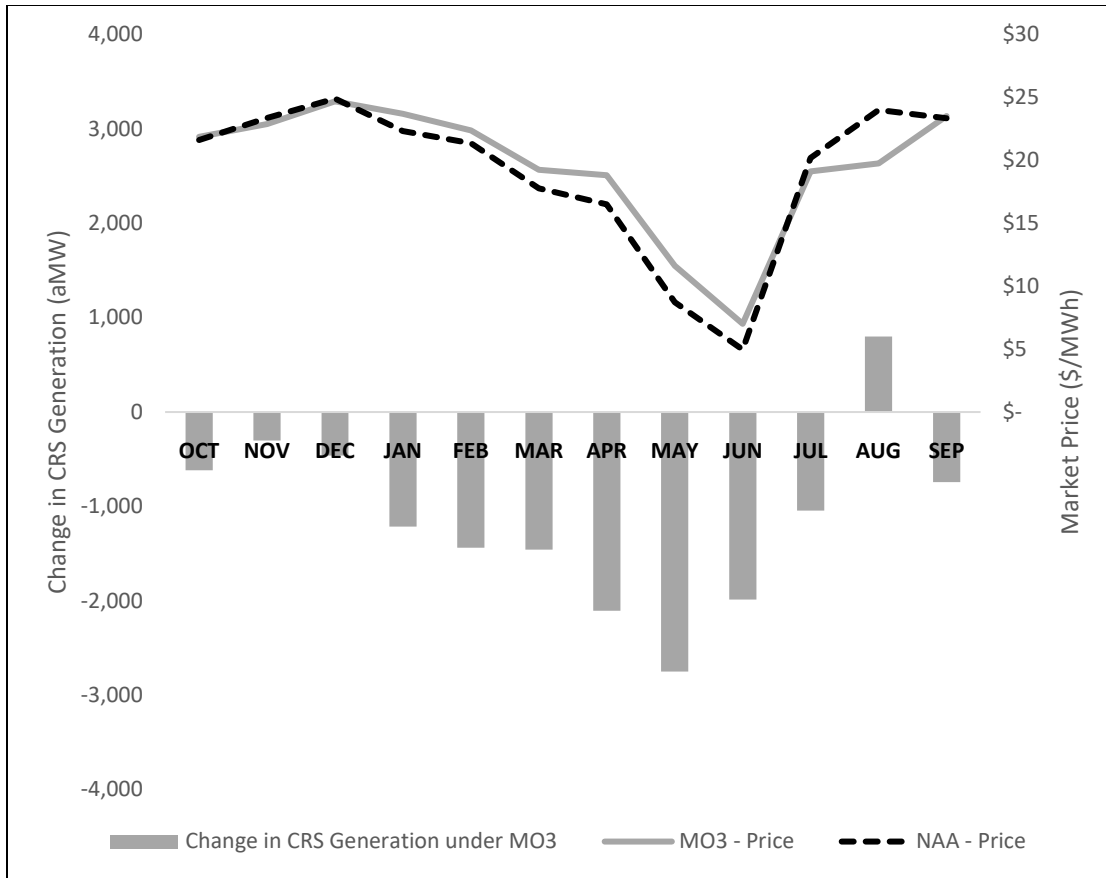


Figure 3-185. Monthly Columbia River System Generation (aMW) and Market Price (\$/MWh)

Note: The right axis is the market price (\$/MWh). The left axis is generation from the CRS projects by month (aMW).

Source: Power Analysis

27957
 27958
 27959
 27960
 27961

27962 Bonneville Wholesale Transmission Rate Pressure

27963 Increased capital costs (between about \$167 million and \$243 million of direct costs, depending
 27964 on resource replacement portfolio) associated with the interconnections and a reinforcement
 27965 project combined with the changes in short- and long-term sales and market pricing would
 27966 result in an upward transmission rate pressure. Upward transmission rate pressures would
 27967 range from 1.3 percent annually (11 percent over an 8-year period) for the least-cost portfolio
 27968 and 1.5 percent annually (13 percent over an 8-year period) under the zero-carbon portfolio,
 27969 relative to the No Action Alternative. Across customers and portfolios, the range of annualized
 27970 upward rate pressures would be from 0.60 to 3.2 percent.

27971 Retail Rate Effects

27972 The retail rate that end users pay to their individual utilities for electricity would experience
 27973 upward rate pressure under MO3 compared to the No Action Alternative. Should the upward
 27974 rate pressure lead to increases in rates, the average retail rates under MO3 would range from
 27975 10.36 cents per kWh to 10.57 cents per kWh for residential end users depending on the

27976 replacement resource portfolio. The rates across portfolios were also similar between
27977 portfolios for commercial and industrial end users. On average, counties would experience a
27978 1.6 to 3.6 percent upward rate pressure in residential retail rates depending on the
27979 replacement portfolio compared to the No Action Alternative with the zero-carbon portfolio
27980 having higher retail rate effects. Customers of utilities receiving power from Bonneville would
27981 experience greater upward rate pressure. The largest upward rate pressure across counties
27982 would be 15 percent.

27983 **BONNEVILLE FINANCIAL ANALYSIS**

27984 As previously described, the Bonneville financial analysis considers the effects of the MOs on
27985 future cash flows over a 30-year financing period for potential replacement resources.
27986 For MO3, the discounted NPV of the cash flow effects under each resource replacement
27987 portfolio is described in Table 3-168 below. This NPV analysis is Bonneville specific and does not
27988 capture wider societal impacts. This NPV analysis uses a risk adjusted discount rate of
27989 7.9 percent and a 30-year timeframe.

27990 The sensitivities in this analysis are described in the Power Rates section, above.

27991 **Table 3-168. Bonneville Financial Analysis Results (in Millions \$2019)**

Analysis Type	MO3	
	Zero Carbon	Conventional Least-Cost
Power	-\$4,610	-\$1,866
Transmission	-\$221	-\$171
Total Base Impact – Bonneville	-\$4,830	-\$2,037

27992 **DEBT OUTSTANDING ON THE LOWER SNAKE RIVER DAMS**

27993 Bonneville manages its debt as a single portfolio and makes choices about debt repayment
27994 based on its financial strategies. For instance, since 2002, Bonneville has worked with Energy
27995 Northwest (EN) to refinance EN’s debt as it came due which then allowed Bonneville to
27996 accelerate the repayment of Treasury bonds, to extend access to limited Treasury borrowing
27997 authority, or to reduce interest costs by accelerating the repayment of higher interest rate
27998 Congressional appropriations. In these cases, it can be said that significant non-Federal debt is
27999 indirectly supporting Federal generation assets. Identifying the amount of outstanding debt is
28000 further complicated because the source of financing is not associated with specific capital
28001 investments, with the exception of some Congressional appropriations or Transmission
28002 Services’ lease financing program. Because of this, it is not possible to precisely determine the
28003 amount of debt outstanding that is associated with the lower Snake River projects or the
28004 associated hatchery facilities of the LSRCF.

28005 However, while it is not possible to definitively identify the amount of debt outstanding, it can
28006 be estimated using the debt to asset ratio for Bonneville’s Power Services. The debt to asset
28007 ratio compares the total amount of debt associated with Bonneville’s business units with its

28008 revenue generating assets. At the end of FY 2019, the Power Services’ ratio was 86.6 percent.
 28009 This ratio is arguably too low for this purpose because of a change in FY 2019 of the accounting
 28010 treatment for the future decommissioning costs of the Columbia Generating Station (CGS)
 28011 nuclear power plant that increased the value of the non-Federal generation asset in the
 28012 equation. The value of the decommissioning cost is the present value of a future cost that will
 28013 be funded by cash contributions to a trust fund and earnings on the fund, not by the issuance of
 28014 debt. Adjusting for this change produces a ratio of 93.64 percent. At the end of FY 2019,
 28015 Bonneville estimates that the lower Snake River projects had a net investment value of
 28016 \$1.2 billion. If the LSRCF facilities are included in the total, the net investment value is
 28017 \$1.4 billion. Using the two debt to asset ratios and the possible net investment values, the
 28018 portion of Bonneville outstanding debt for these assets ranges from \$1.0 billion to \$1.3 billion
 28019 (Table 3-169).

28020 **Table 3-169. Bonneville Outstanding Debt (\$)**

FY 2019	Lower Snake Dams Only	Lower Snake Dams + Lower Snake Compensation Plan
Debt to Asset Ratio (86.59%)	\$1,300,300,000	\$1,203,537,000
Adjusted Ratio (93.64%)	\$1,123,919,000	\$1,301,527,000

28021 **SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION**

28022 **Social Welfare Effects**

28023 This social welfare analysis employs both the market price and production cost methods based
 28024 on the base case for this analysis, assuming no additional coal plant retirements. Section
 28025 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*, describes the differences
 28026 between these two methods. Table 3-170 presents the market value of the reduction in Pacific
 28027 Northwest hydropower generation under MO3 as compared with the No Action Alternative.
 28028 Based on the market price method, the average annual economic effect due to decreases in
 28029 hydropower generation under MO3 is a \$150 million cost. If these social welfare effects persist
 28030 over a 50-year timeframe, the present value cost would be \$4.2 billion.

28031 **Table 3-170. Average Annual Social Welfare Effect of Multiple Objective 3 Based on the**
 28032 **Market Price of Changes in Pacific Northwest Hydropower Generation (2019 U.S. Dollars)**

Change in Generation (aMW)	Change in Generation (MWh)	Average Annual Social Welfare Effect
-1,100	-10,000,000	-\$150,000,000

28033 Table 3-171 evaluates the social welfare effects of MO3 based on the additional costs of adding
 28034 enough new resource capacity to the system to meet power demand given the reduction in
 28035 hydropower generation described in Table 3-159,. Based on this approach, the social welfare
 28036 effects of MO3 range from an average annual cost of \$270 million (assuming a least-cost
 28037 replacement resource portfolio) to \$540 million (assuming a zero-carbon replacement resource

28038 portfolio). If these social welfare effects persist over a 50-year timeframe, the present value
28039 costs would be \$7.4 billion to \$15 billion.

28040 **Table 3-171. Average Annual Social Welfare Effect of Multiple Objective 3 Based on the**
28041 **Increased Cost of Producing Power to Meet Demand (2019 U.S. Dollars)**

Production Cost Factor ^{1/}	Replacement Resource Portfolio	
	Zero Carbon	Conventional Least Cost
Annualized Fixed Cost of Replacement Resources	-\$420,000,000	-\$140,000,000
Annualized Fixed Cost of Transmission Infrastructure	-\$13,000,000	-\$9,100,000
Average Annual Variable Costs	-\$110,000,000	-\$130,000,000
Average Annual Social Welfare Cost	-\$540,000,000	-\$270,000,000

28042 Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

28043 1/ Negative values in the table represent an increase (net cost) in the cost of producing power.

28044 **Regional Economic Effects**

28045 Estimated average residential retail electricity rates would experience upward rate pressure
28046 under MO3 with increases up to 3.6 percent in certain counties across the zero-carbon
28047 portfolios and 1.6 percent for the least-cost portfolios. The highest upward pressure could
28048 occur for industrial customers with a maximum increase of 29 percent in some counties for
28049 industrial end users. These retail rate pressures could negatively affect residential, commercial,
28050 and industrial end users due to the increase in spending on electricity relative to the No Action
28051 Alternative.

28052 **Residential Effects**

28053 Examining potential upward residential retail rate pressure on a geographic basis, the effects of
28054 MO3 would negatively affect residential end users across the Pacific Northwest. Many
28055 residential end users would experience average upward rate pressure greater than 5 percent
28056 relative to the No Action Alternative—much higher than historical year-to-year rate changes.
28057 The upward residential rate pressure under MO3 would range as high as 15 percent for certain
28058 counties, with average changes above 1.5 percent for all portfolios and financing assumptions.
28059 Some utilities that do not purchase power from Bonneville could be largely isolated from the
28060 higher rate effects; however, MO3 could result in higher regional total production costs and
28061 higher market prices generating adverse rate effects on utilities that do not purchase power
28062 from Bonneville.

28063 Under MO3, the largest residential rate pressure effects would occur in urban areas that are
28064 not adjacent to metropolitan areas. In these urban non-metropolitan areas under the zero-
28065 carbon portfolio, average upward rate pressure effects of 3.0 to 4.5 percent would occur,
28066 depending on the financing portfolio. Rural and smaller areas under MO3 would experience
28067 smaller rate pressure increases relative to the No Action Alternative ranging from 0.8 to
28068 3.4 percent, depending on the portfolio. Table 3-172 presents the average rate increase by
28069 CRSO region. Under MO3, Region D would experience the highest average residential rate
28070 pressure increases ranging from 2.4 to 5.0 percent, depending on the portfolio. Region A would

28071 also experience higher rate increases ranging from 1.6 to 4.6 percent, depending on the
28072 portfolio.

28073 **Table 3-172. Average Residential Retail Rate Pressure Effect of Multiple Objective 3 by**
28074 **Columbia River System Operations Region**

CRSO Region	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Region A	4.6%	1.6%	3.1%	1.2%
Region B	2.4%	1.6%	3.5%	2.0%
Region C	1.7%	1.0%	1.3%	0.92%
Region D	4.2%	2.4%	5.0%	2.8%
Other	3.6%	1.6%	3.1%	1.5%

28075 Figure 3-186 shows potential residential rate pressure effects under MO3 relative to the No
28076 Action Alternative. Negative effects (i.e., upward rate pressure) would occur across the region
28077 with multiple counties experiencing small changes, especially in southwestern Idaho and
28078 Montana. The highest effects would occur in a zero-carbon Bonneville-financed portfolio.

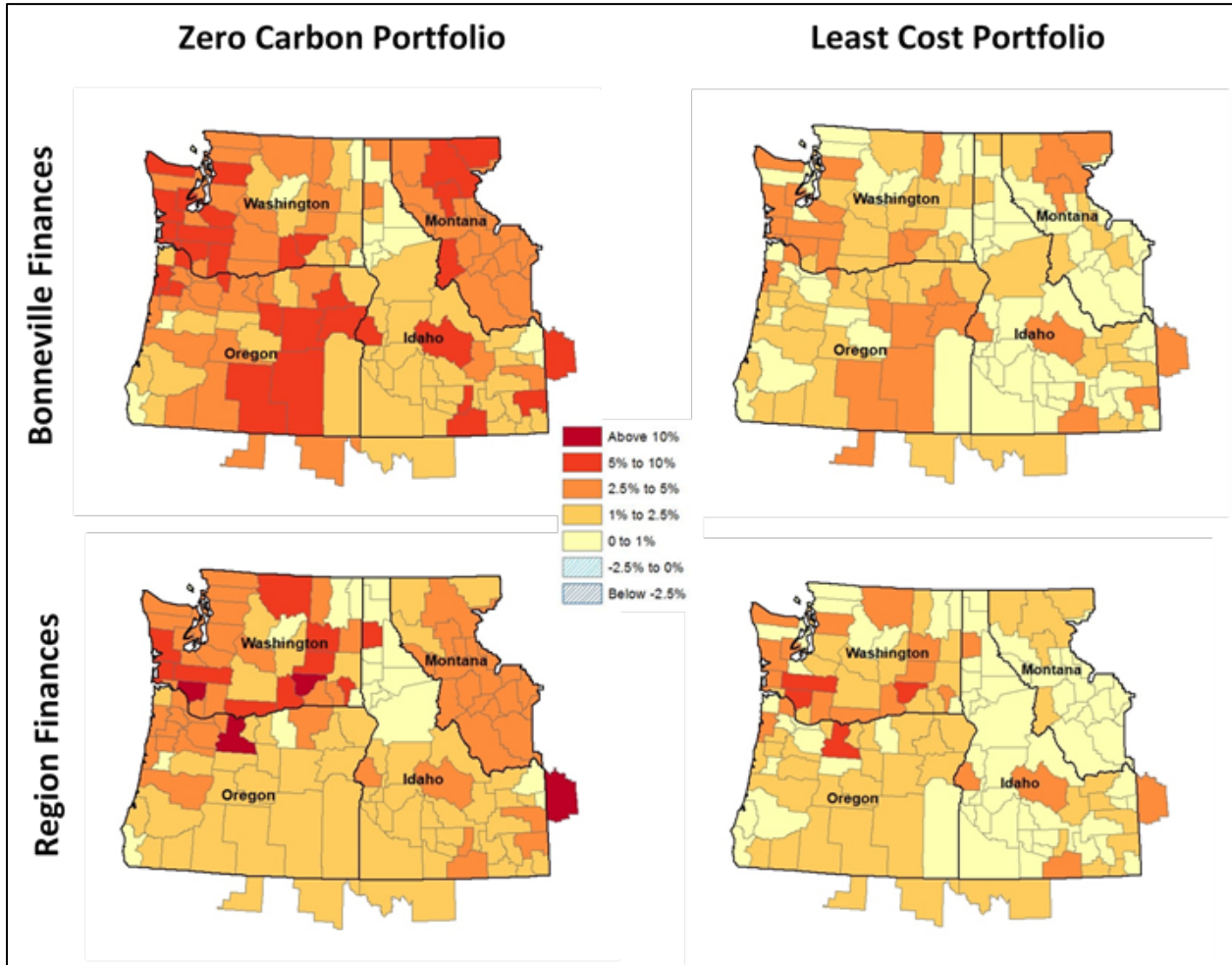
28079 The upward retail rate pressure would be constant after 2030. Considerable uncertainty
28080 surrounds load and rate pressures over time; however, the changes under MO3 would be
28081 expected to extend similarly adverse effects over the long term for end user retail rates
28082 (Table 3-173).

28083 To the extent that the upward rate pressure leads to changes in rates, end users would increase
28084 spending on electricity. As a portion of income, residential end users in MO3 could spend
28085 between 1.72 and 1.75 percent of their income on electricity—an increase over the No Action
28086 Alternative. Averaging across counties, the fraction of income spent on electricity would
28087 increase by 0.03 to 0.06 percent for the average household, depending on the portfolio. Cowlitz
28088 County, Washington, would experience the largest increase under MO3 compared to the No
28089 Action Alternative—an increase of up to 14 percent in the fraction of income (from 1.6 percent
28090 of income to 1.9 percent of income) spent on electricity for a household—because customers
28091 there would have a relatively low initial rate under the No Action Alternative. The total increase
28092 in household spending on electricity across all Pacific Northwest households would be between
28093 \$92 million and \$210 million per year, depending on the portfolio.

28094 Examining average expenditures, under MO3 the average residential end user would spend
28095 between \$16 and \$38 more per year on electricity. The highest effects across the Pacific
28096 Northwest would result in up to \$130 more spent per year on electricity compared to the No
28097 Action Alternative.

28098 Categorizing the number of households by expenditure change shows the differences each
28099 financing portfolio would have (Table 3-174). Under a zero-carbon Bonneville-financed
28100 portfolio, 21 percent of all households would experience increases greater than 5 percent.
28101 Across all portfolios, between 3.1 percent (zero-carbon) and 37 percent (least-cost) of all

28102 households would experience a minimal change between 0 and 1 percent relative to the No
 28103 Action Alternative.



28104
 28105 **Figure 3-186. Residential Electricity Rate Pressure Effects by Portfolio for Multiple Objective 3**
 28106 **for the Base Case without Additional Coal Plant Retirements**

28107 **Table 3-173. Average Upward Retail Rate Pressure Effect in 2022 and 2041 under Multiple**
 28108 **Objective 3 Relative to the No Action Alternative for the Base Case without Additional Coal**
 28109 **Plant Retirements**

Financing	Portfolio	Residential		Commercial		Industrial	
		2022	2041	2022	2041	2022	2041
Bonneville	Zero-Carbon	3.6% 3.6%	5.0% 5.0%	4.1% 4.0%	5.5% 4.9%	5.2% 4.8%	6.6% 5.7%
	Conventional Least-Cost	1.6% 1.6%	2.9% 2.8%	1.7% 1.7%	2.9% 2.5%	2.3% 2.0%	3.5% 2.8%
Region	Zero-Carbon	3.4% 3.3%	4.8% 4.7%	3.8% 3.5%	5.2% 4.4%	4.8% 4.2%	6.2% 5.1%
	Conventional Least-Cost	1.6% 1.5%	2.8% 2.8%	1.7% 1.6%	2.9% 2.4%	2.2% 1.9%	3.5% 2.7%

28110 **Table 3-174. Percentage of Residential End Users Who Experience Changes in Electricity**
 28111 **Expenditures by Size of Expenditure Change in each Portfolio under Multiple Objective 3**

Sector	Expenditure Change	Bonneville Finances		Region Finances	
		Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Residential	>+10%	0%	0%	1.6%	0%
	+5 to 10%	21%	0%	4.8%	2.0%
	+2.5 to 5%	58%	20%	70%	12%
	+2.5% to 1%	18%	44%	20%	49%
	+0% to 1%	3.1%	37%	3.9%	37%
	Decrease	0%	0%	0%	0%

28112 Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

28113 Under MO3, expenditures and rates would increase, which would likely result in end users
 28114 reducing their consumption based on the elasticity of demand (EIA 2014). Many counties that
 28115 would experience high increases in rates would adjust consumption to reduce their annual
 28116 expenditures. If the average household reduced consumption, then the costs under MO3 would
 28117 be reduced by between \$16 and \$38 per year. In counties where the increase in rates would be
 28118 highest, due to these higher costs and decreased consumption, households could save up to
 28119 \$130 per year in the most extreme expenditure portfolios to offset some of the increased costs
 28120 from MO3 (Bonneville-financed zero-carbon portfolio).

28121 This analysis considers how the region wide changes in household spending on electricity would
 28122 affect demand for other goods and services across the region. That is, the increased spending
 28123 on electricity may reduce spending on other items, affecting regional economic productivity.
 28124 This analysis applies IMPLAN to model the increased spending on electricity as a reduction in
 28125 household income (direct effect) and quantifies the multiplier effects on interrelated economic
 28126 sectors (indirect and induced effects). This analysis finds that the potential increased cost of
 28127 household electricity could result in the loss of between \$97 million and \$230 million in regional
 28128 output (sales) and between 620 and 1,500 jobs (Table 3-175). The majority of regional
 28129 economic effects would occur in Washington and Oregon.

28130 **Table 3-175. Regional Economic Effects from Changes in Household Spending on Electricity**

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Output	-\$230 million	-\$99 million	-\$210 million	-\$97 million
Value Added	-\$130 million	-\$59 million	-\$120 million	-\$58 million
Labor Income	-\$75 million	-\$33 million	-\$69 million	-\$32 million
Employment	-1,500 jobs	-630 jobs	- 1,400 jobs	-620 jobs

28131 Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional
 28132 economy

28133 Commercial and Industrial Effects

28134 Commercial and industrial retail rates would also experience upward rate pressure under MO3
28135 across the region compared to the No Action Alternative. The average commercial retail rate
28136 under MO3 would experience upward rate pressure of 1.7 to 4.1 percent, depending on the
28137 replacement portfolio. Areas with large numbers of commercial entities (King, Pierce,
28138 Snohomish, and Multnomah Counties) would continue to have relatively low rates but some,
28139 under a Bonneville-financed zero-carbon portfolio (i.e., highest rate effect), would experience
28140 upward rate pressure ranging as high as 7.4 percent in Snohomish County, 5.5 percent in Pierce
28141 County, 3.8 percent in King County and 4.2 percent in Multnomah County relative to the No
28142 Action Alternative. Under the other portfolios the upward pressure effects for all would be
28143 smaller.

28144 These upward rate pressures under MO3 could lead to increasing expenditures on electricity for
28145 commercial and industrial entities. For commercial end users, the increases would be as high as
28146 an average of \$960 per year in certain counties that represent an 8.1 percent increase in
28147 electricity expenditures. Because industrial end users tend to require large amounts of
28148 electricity, the total amount of electricity expenditures would increase by as much as
28149 \$16,000 per year. The highest percentage increase and dollar increase would not occur in the
28150 same county, as the largest percentage change would occur in a county with a lower base rate.
28151 The highest percentage increase is a 28 percent increase in electricity expenditures for the
28152 highest example of impact on industrial end users, which could cause these end users' demand
28153 to fall between 3 and 28 percent, depending on the responsiveness (i.e., elasticity) of the
28154 industrial end users to changes in electricity price (EIA 2018a). In addition to lowered electricity
28155 use among individual businesses, large rate increases could cause industry to leave the region.
28156 Historically, the region had a large aluminum industry, but past increases in electricity prices
28157 contributed to those industries shutting down operations in the region, largely in favor of
28158 production in other countries (NW Council 2018a). Additional large price increases associated
28159 with MO3 could similarly cause electricity-heavy industries to shift production out of the region
28160 (Table 3-176).

28161 Table 3-176. Percentage of Commercial and Industrial End Users Who Experience Changes in
28162 Electricity Expenditures by Size of Expenditure Change under Multiple Objective 3

Sector	Expenditure Change	Bonneville Finances		Region Finances	
		Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Commercial	>+10%	0%	0%	3.5%	0%
	+5 to 10%	19%	1.1%	2.0%	2.9%
	+2.5 to 5%	61%	22%	73%	17%
	+2.5% to 1%	17%	45%	18%	43%
	+0% to 1%	2.6%	32%	3.0%	37%
	Decrease	0%	0%	0%	0%

Sector	Expenditure Change	Bonneville Finances		Region Finances	
		Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Industrial	>+10%	4.8%	0%	4.3%	0.52%
	+5 to 10%	40%	12%	37%	11%
	+2.5 to 5%	40%	18%	46%	17%
	+2.5% to 1%	13%	52%	10%	52%
	+0% to 1%	2.7%	18%	2.8%	19%
	Decrease	0%	0%	0%	0%

28163 Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

28164 Under MO3, the upward rate pressure across commercial businesses in the Pacific Northwest
28165 would be between \$30 million and \$70 million per year. This analysis uses the IMPLAN model to
28166 quantify the multiplier effects of the change in commercial sector productivity (Table 3-177).
28167 The multiplier effects reflect how the increased costs of doing business may affect demand for
28168 inputs to production across commercial businesses. This analysis finds that the increased cost
28169 of electricity to regional commercial businesses would result in the loss of between \$49 million
28170 to \$120 million in regional output (sales) per year and between 330 to 810 jobs. The majority of
28171 regional economic effects would occur Washington and Oregon.

28172 **Table 3-177. Regional Economic Effects from Changes in Commercial Business Spending on**
28173 **Electricity**

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Output	-\$120 million	-\$49 million	-\$110 million	-\$49 million
Value Added	-\$72 million	-\$31 million	-\$68 million	-\$31 million
Labor Income	-\$37 million	-\$16 million	-\$35 million	-\$16 million
Employment	- 810 jobs	- 330 jobs	- 750 jobs	- 330 jobs

28174 Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional
28175 economy.

28176 Under MO3, the total increase in spending on electricity across industrial businesses in the
28177 Pacific Northwest would be between \$100 million and \$240 million per year. Similar to the
28178 commercial spending analysis, the IMPLAN model is used to quantify the multiplier effects of
28179 the change in industrial sector productivity (Table 3-178). This analysis finds that the increased
28180 cost pressure of electricity to regional industrial businesses would result in the loss of
28181 \$170 million and \$400 million in regional output (sales) and between 1,000 jobs and 2,700 jobs.
28182 Again, the majority of regional economic effects would occur Washington and Oregon.

28183 **Table 3-178. Regional Economic Effects from Changes in Industrial Business Spending on**
28184 **Electricity**

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Output	-\$400 million	-\$170 million	-\$370 million	-\$170 million
Value Added	-\$250 million	-\$110 million	-\$230 million	-\$110 million

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Labor Income	-\$130 million	-\$56 million	-\$120 million	-\$55 million
Employment	-2,700 jobs	- 1,100 jobs	-2,400 jobs	-1,100 jobs

28185 Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional
28186 economy.

28187 The effects on commercial and industrial businesses described above are predicated on the
28188 region acquiring replacement resources for the reduction in hydropower generation. If the
28189 replacement resources are not developed, there would be an increase in risk to power system
28190 reliability. Power shortages might occur in about an eighth of the years, with some years
28191 experiencing more than one event. These power shortages (blackouts) would have adverse
28192 effects on businesses.

28193 **Other Social Effects**

28194 There would be retail rate increases across the region under MO3. These rate increases could
28195 lead certain end users to forego normal expenditures, even if only slightly, from the increased
28196 energy burden from electricity costs. End users often forgo heating and cooling as well as food
28197 purchases due to higher energy bills. MO3 would increase the likelihood of such occurrences
28198 relative to the No Action Alternative because household spending on electricity would increase.
28199 These effects would be more likely in areas where the highest portion household income goes
28200 to electricity bills. These instances of forgoing purchases or inadequately heating or cooling a
28201 home would have negative health effects (EIA 2015).

28202 Power reliability would likely return to the No Action level if replacement resources were put
28203 online and transmission system reinforcement near the Tri-Cities occurred. Thus, there would
28204 likely not be additional safety concerns from a large-scale outage compared to the No Action
28205 Alternative, if replacement resources and reinforcement were put online. If either the
28206 replacement resources or the transmission system reinforcement did not occur, then there
28207 would be reliability issues due to changes in transmission flows. Similarly, if the region
28208 (Bonneville or other regional entities) did not acquire additional resources or the new resources
28209 were not available before generation from the lower Snake River projects ended, there would
28210 be an increased risk of power shortages, which would lead to additional safety concerns. Power
28211 shortages (blackouts) would occur more frequently in the winter and would become an issue in
28212 the summer as well. Safety concerns include heating and cooling, hospitals and other power-
28213 dependent medical support, lighting for safety, and traffic lights.

28214 **SUMMARY OF EFFECTS**

28215 Hydropower generation from the CRS projects would decrease by over 10 percent, or
28216 1,100 aMW (roughly the amount of power consumed by about 900,000 Northwest homes in a
28217 year), compared to the No Action Alternative. The FCRPS would lose over 10 percent of the firm
28218 power available for long-term firm power sales to preference customers. This decrease in

28219 hydropower generation would increase LOLP, meaning there would be an increased chance of
28220 substantial power outages.

28221 The reduction in hydropower generation across the Pacific Northwest (a reduction of
28222 1,400 aMW including Federal and non-Federal projects) would result in an average annual
28223 economic cost of \$150 million when valued at the market price for the foregone power
28224 generation. However, the estimated increase in the marginal cost of producing power to meet
28225 demand based on additional average annual fixed and variable costs is \$270 million to
28226 \$540 million. If these social welfare effects persist over a 50-year timeframe, the present value
28227 cost is up to \$15 billion. These values are estimates of the net economic effects from a national
28228 societal perspective.

28229 To avoid loss of load events (power outages), large amounts of new capacity would need to be
28230 brought online through replacement resources to bring the LOLP of MO3 to the No Action level.
28231 Consequently, residential and industrial end users would experience upward retail rate
28232 pressure effects of up to 8.1 and 13 percent in their rates and spending on electricity, with
28233 21 percent of households experiencing greater than a 5 percent upward rate pressure under
28234 the Bonneville-finance zero-carbon portfolios. Depending on the customer class, the effects
28235 expected from upward rate pressure up to 13 percent under MO3 would be adverse and major.

28236 The increased cost of electricity could increase the costs of living and doing business in the
28237 Pacific Northwest, resulting in regional economic impacts of \$740 million in lost output (sales)
28238 and 4,900 jobs.

28239 In the scenarios with limited or no coal generation in the region, the upward rate pressure
28240 associated with MO3 would likely be substantially higher. Regional utilities that purchase most
28241 or all of their power from Bonneville would experience larger effects than IOUs or other public
28242 utilities that do not purchase Bonneville power directly (Table 3-179).

28243 **Table 3-179. Summary of Effects under Multiple Objective 3 without Additional Coal Plant**
28244 **Closures**

Effect	No Action Alternative ^{1/}	MO3 Relative to No Action
CRS Hydropower generation (aMW)	8,300	-1,100
Firm power of FCRPS (aMW)	7,100	-730
LOLP	6.6%	+7.3 LOLP %
Replacement resources to return LOLP to NAA level	— ^{1/}	1,120 MW natural gas or 2,550 MW solar and 600 MW demand response
Replacement resource cost to return LOLP to NAA level (annual cost)	— ^{1/}	+\$230 million or +\$420 million
Transmission infrastructure to return LOLP and/or transmission system reliability to NAA level (annualized reinforcement and/or interconnection cost)	— ^{1/}	\$9.1 million to \$13 million

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Effect	No Action Alternative^{1/}	MO3 Relative to No Action
Average Bonneville wholesale power rate pressure (base analysis)	\$34.56	+8.2% to +19.3%
Potential Range of Bonneville wholesale power rate (\$/MWh)		\$37.41/MWh to \$41.23/MWh
Potential range of Bonneville wholesale power rate pressure including rate sensitivities		4.1% to 50.3%
Annualized transmission rate pressure relative to NAA (%)	— ^{1/}	+1.3% to +1.5%
Average annual social welfare effects (\$): market price method estimate	—	-\$150 million
Average annual social welfare effects (\$): production cost method estimate	— ^{2/}	-\$270 million to -\$540 million
Residential rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	10.21	+1.6% to +3.6% (+0.06% to 15%)
Commercial rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	8.89	+1.7% to +4.1% (+0.07% to 15%)
Industrial rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	7.25	+2.2% to +5.2% (+0.10% to 29%)
Regional Economic Productivity Effects: Change in Output	— ^{1/}	-320 million to -\$740 million
Regional Economic Productivity Effects: Change in Employment	— ^{1/}	-2,100 jobs to -4,900 jobs
Share of households experiencing >5% increase in rates relative to NAA, highest across portfolios	— ^{1/}	21%
Share of businesses with >5% increase in rates relative to NAA, highest across portfolios	— ^{1/}	26%
Regional Cost of Carbon Compliance		\$34 to \$623 million/year

28245 NOTE: The estimated LOLP effect, and resulting social welfare and rate effects, rely on the best available
28246 information regarding planned coal plant retirements as of 2017 when the modeling efforts began for this analysis.
28247 Based on regional energy policy developments and expected coal-plant closures as of 2019, Section 3.7.3.1
28248 discusses the sensitivity of the results of the analysis to these assumptions.

28249 1/ The analysis of the No Action Alternative for these effect categories provides a baseline against which the MOs
28250 are compared. Thus, the No Action Alternative results presented in this table describe the baseline magnitude of
28251 power and transmission values (e.g., for LOLP and rates) and the MO3 results describe the change relative to the
28252 No Action Alternative. A “—” indicates an effect category that is not relevant to the No Action Alternative
28253 because it only occurs as a result of implementing the MOs (e.g., the need for new generation and transmission
28254 infrastructure and associated costs).

28255 2/ The production cost method for valuing social welfare effects of the MOs relies on information on the fixed and
28256 variable costs of replacement generation resources. These costs are not relevant to the No Action Alternative.

28257 **3.7.3.6 Multiple Objective Alternative 4**

28258 This section evaluates effects under MO4. Large increases in spring and summer fish passage
28259 spill under this alternative would reduce hydropower generation from the CRS projects
28260 compared to No Action Alternative. And the addition of up to 2 million acre-feet of water for

28261 spring and early summer flow augmentation in drier years would further reduce generation by
28262 late summer. Therefore, a large portfolio of replacement resources would be required to bring
28263 the LOLP to the No Action Alternative level. The need for replacement resources would result in
28264 the highest level of upward rate pressure of any of the MOs compared to the No Action
28265 Alternative in the base case without additional coal plant retirements.

28266 **CHANGES IN POWER GENERATION**

28267 Table 3-180 and Figure 3-187 present the generation for the No Action Alternative and MO4
28268 and their differences by month. Overall, generation from the CRS projects would decrease by
28269 1,300 aMW from 8,300 aMW under the No Action Alternative to 7,000 aMW under MO4 (on
28270 average, for the 80 historical water conditions). This represents a greater than 15 percent
28271 decrease in generation. The decrease in generation from the regional hydropower system,
28272 including the non-Federal projects is 1,340 aMW. Although generation would decrease
28273 throughout most of the year, the largest decreases would occur from March through the end of
28274 August due to the *Spill to 125% TDG* measure. With this level of spill, the eight fish passage
28275 projects would mostly be generating only at their minimum generation levels except for a few
28276 months in the wettest water years. The *McNary Flow Target* measure would also have a large
28277 impact on generation as it increases flows in the spring in the drier years resulting in reduced
28278 flows in the late summer and fall. In August in particular, the combination of spill at the fish
28279 passage projects and lower flows that impact generation at Grand Coulee and Chief Joseph
28280 would combine to reduce generation in a month when heat waves can lead to high loads and
28281 reliability challenges.

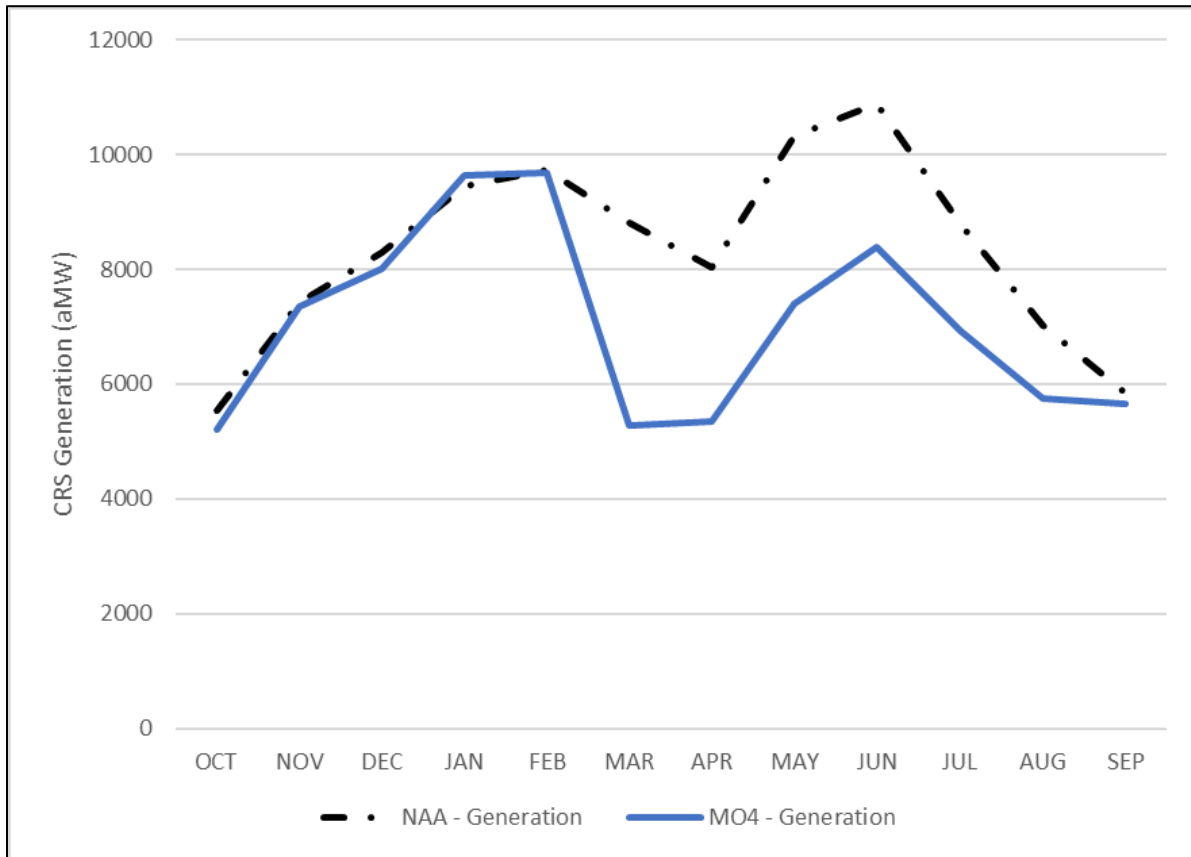
28282 **Table 3-180 Columbia River System Monthly Generation under Multiple Objective 4 Relative**
28283 **to the No Action Alternative, aMW**

Month ^{1/}	NAA	MO4 Generation Difference	MO4 % Difference
October	5,500	-330	-6%
November	7,400	-79	-1%
December	8,300	-300	-4%
January	9,500	190	2%
February	9,700	-35	0%
March	8,800	-3,500	-40%
April I	7,800	-2,900	-37%
April II	8,200	-2,400	-30%
May	10,000	-2,900	-28%
June	11,000	-2,500	-23%
July	8,800	-1,900	-21%
August I	7,600	-1,500	-19%
August II	6,500	-1,100	-17%
September	5,800	-180	-3%
Annual Total	8,300	-1,300	-16%

28284 Notes: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
28285 HYDSIM modeling inadvertently omitted the impact of the *Winter System FRM Space* in December of some years,

28286 which would move some generation (0 to 450 MW depending on the year) from January into December. This
28287 operation would not change the conclusions of the analysis.
28288 1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these
28289 months tend to have substantial natural flow differences between their first and second halves.
28290 Source: HYDSIM modeling results

28291 Figure 3-187 presents the monthly generation of the CRS for MO4 and the No Action
28292 Alternative.



28293
28294 **Figure 3-187. Monthly Hydropower Generation at the Columbia River System Projects, No**
28295 **Action Alternative and Multiple Objective 4, in aMW**

28296 The critical water year generation of the CRS projects would decrease by 14 percent (-890
28297 aMW) and the amount of firm power available for meeting Bonneville's long-term supply
28298 obligations would decrease by 870 aMW. The decrease would be largest in June when
28299 generation decreases by 30 percent, but the decrease would be most critical in August when
28300 generation is already low in the No Action Alternative. The ability of CRS projects to meet peak
28301 load and heavy load periods would both decrease by 13 percent (from 11,000 aMW in No
28302 Action to 9,400 aMW in MO4 for the peak hours).

28303 Other regional hydropower projects that are located downstream of certain CRS projects (such
28304 as the non-Federal mid-Columbia projects) would experience similar trends in hydropower
28305 generation to the CRS projects as a result of flow changes but would not be affected by

28306 increasing spill to 125% TDG. The regional hydropower system (including these non-CRS
28307 projects) under MO4 would generate 12,000 aMW on average. This represents a 10 percent
28308 decrease in power generation relative to the No Action Alternative. The CRS projects account
28309 for 1,303 aMW of the 1,339-aMW decrease under MO4 due to spill and flow changes.

28310 Based on a qualitative assessment of the alternative, MO4 would substantially decrease the
28311 flexibility of operating the CRS projects, primarily in spring and summer due to the increased
28312 spill, which would decrease the ability to integrate other renewable resources into the power
28313 grid.

28314 **EFFECTS ON POWER SYSTEM RELIABILITY**

28315 The increased spill and flow in spring and summer would lead to an increase in LOLP to
28316 30 percent under MO4, which is 23 percentage points higher than the No Action Alternative.
28317 The largest effects on LOLP would result from changes in generation from March to August, and
28318 this range includes the summer months when demand for electricity is high. A 30 percent LOLP
28319 is roughly the equivalent to a one-in-three likelihood of there being one or more loss of load
28320 events in 2022 (e.g., blackouts or emergency power measures such as were implemented in
28321 2001 during the West Coast power crisis), and is more than three times the LOLP of the No
28322 Action Alternative.

28323 As described in Section 3.7.3.2, *No Action Alternative*, these LOLP estimates rely on the
28324 assumption that 4,246 MW of coal generating capacity would continue to serve regional loads
28325 over the period of analysis. In future scenarios with limited to no coal capacity, the LOLP under
28326 MO4 would increase by 28 percentage points (from 27 percent to 55 percent) (limited coal) and
28327 18 percentage points (from 63 percent to 81 percent) (no coal), compared to the No Action
28328 Alternative. Under the no-coal scenario, the difference in LOLP for MO4 versus the No Action
28329 Alternative would be smaller than under the base analysis with more coal generation. The No
28330 Action Alternative without coal generation would require about 28,000 MW of zero-carbon
28331 resource additions for generation year-round to restore the LOLP to 6.6 percent. Based on
28332 current technology, the majority of that would be solar, which would be more effective in the
28333 summer than in the winter. Because MO4 would have the largest LOLP in the summer, the
28334 added solar to reach the No Action alternative level would help reduce the LOLP issues from
28335 MO4.

28336 **POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS**

28337 To maintain power system reliability in the Northwest, additional generation resources would
28338 be needed. However, construction of new resources (e.g., gas, solar, wind, or pumped storage)
28339 and new transmission can easily take a decade to implement for planning, permitting, land
28340 acquisition, and physical construction. Setting aside the timing of construction, under the least-
28341 cost replacement generation portfolio, returning LOLP to the No Action Alternative level would
28342 require about 3,240 MW of single-cycle natural gas turbines. This portfolio would cost
28343 \$156 million annually (2019 dollars), including annualized capital costs, fixed operations and
28344 maintenance, and insurance. The transmission analysis assumed these would be located in

28345 northeastern Oregon and southeastern Washington, which would optimize accessibility to an
28346 existing gas pipeline and transmission capacity. This does not include the annual cost of fuel to
28347 generate power, nor variable operation and maintenance costs. During critical water
28348 conditions, fuel plus variable costs would cost roughly \$86 million annually (2019 dollars).

28349 Under the zero-carbon resource portfolio, about 5,000 MW of solar power located across
28350 central Oregon, southern Idaho, and southeastern Washington, with 600 MW of demand
28351 response would reduce LOLP to the No Action Alternative level. The transmission analysis
28352 assumed solar would be located in central Oregon based on proposed projects in the
28353 interconnection queue but then also included adjacent areas with similar high solar output
28354 because such a large amount of solar generation would be needed. These solar power
28355 resources would require roughly 30,000 acres of land or roughly 47 square miles. Such a large
28356 buildout of solar capacity would likely result in additional but currently unknown impacts to
28357 natural and cultural resources, which may include vegetation, wildlife habitat, archaeological
28358 resources, and traditional cultural properties. The zero-carbon portfolio would cost \$547
28359 million/year for the solar power and \$20 million⁸¹/year for the demand response (2019 dollars).

28360 In future scenarios with limited coal generation capacity and assuming no new gas plants are
28361 built, restoring LOLP to 6.6 percent would require no incremental zero-carbon resources
28362 beyond what Bonneville (or the region) would already be procuring under MO4 in the base
28363 case. That is, if Bonneville (or the region) acquired 5,600 MW of zero-carbon resources to
28364 return MO4 to a No Action Alternative LOLP of 6.6 percent and either the limited coal capacity
28365 or the no coal capacity scenario occurred, the region would not need to acquire any more
28366 resources than it would have otherwise acquired under the No Action Alternative as a result of
28367 the additional coal retirements. Table 3-181 summarizes these values.

28368 The analysis also does not include the additional amount of generation balancing reserves
28369 needed to integrate new renewable resources under a zero-carbon replacement resource
28370 portfolio. Generation balancing reserves allow grid operators to increase or decrease
28371 generation in response to changes in load and generation. In this analysis, the generation
28372 balancing reserves needed for the No Action Alternative are included in all modeling. However,
28373 additional reserves needed under a zero-carbon replacement resource portfolio have not been
28374 included and would increase the cost of the alternative. Currently, generation balancing
28375 reserves are generally supplied through the flexibility of hydropower or gas-fired generators in
28376 the region. With further technological advances, other options may be available in the future.
28377 MO4 substantially reduces the flexibility of the hydropower system to supply these generation
28378 balancing reserves.

⁸¹ Demand Response costs in zero-carbon scenarios; \$20 million for Bonneville finances, and \$30 million for region finances)

28379 **Table 3-181. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 4 Relative to the No**
28380 **Action Alternative**

Alternative	Base Case Coal Capacity Assumption in EIS (4,246 MW)			More Limited Coal Capacity (1,741 MW)			No Coal Capacity (0 MW)		
	Pre- Resource Build LOLP	Zero- Carbon Resource Build (MW)	Resource Build Relative to No Action (MW)	Pre- Resource Build LOLP	Zero- Carbon Resource Build (MW)	Incremental Resource Build for MO4 as Impacted by Additional Coal Retirement (MW)	Pre- Resource Build LOLP	Zero- Carbon Resource Build (MW)	Incremental Resource Build for MO4 as Impacted by Additional Coal Retirement (MW)
No Action	6.6%	0	0	27%	8,800	0	63%	28,000	0
MO4	30%	5,600	5,600	55%	12,000	0	81%	30,000	0

28381 Notes: The replacement resources for the No Action Alternative include demand-response, wind, and solar. The incremental resource builds under the more
28382 limited coal capacity or no coal capacity scenarios are additive with the resource builds under the base case, so the total effect is 5,600 MW of build in all three
28383 scenarios.

28384 **BONNEVILLE’S FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION**
28385 **PLAN COSTS**

28386 The Base Case analysis in the summary rate table for MO4 includes an estimate of \$281 million
28387 in annual costs (adjusted to 2019 dollars) for the Bonneville Fish and Wildlife Program, which is
28388 consistent with the No Action Alternative. As previously discussed, Bonneville Fish and Wildlife
28389 Program funding decisions are not being made through the CRSO EIS process. However,
28390 Bonneville Fish and Wildlife Program costs are included in the EIS to inform a transparent cost
28391 analysis for each MO, as discussed in Section 3.19. Future budget adjustments would be made
28392 in consultation with the region through Bonneville’s budget-making processes and other
28393 appropriate forums and consistent with existing agreements. In the case of MO4, Bonneville
28394 included a range of potential Fish and Wildlife Program costs to acknowledge the possibility
28395 that MO4 could provide biological benefits to fish and wildlife and that this could, in turn,
28396 reduce the need for some offsite mitigation funded by the Bonneville Fish and Wildlife
28397 Program. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related
28398 to managing its Fish and Wildlife program and also acknowledges the uncertainty around both
28399 the magnitude of biological benefits and the potential impacts on funding, including the timing
28400 of funding decisions. For this reason, potential adjustments to the Bonneville Fish and Wildlife
28401 Program, which are estimated to range up to \$105 million, are analyzed as part of the Rate
28402 Sensitivity analysis.

28403 Under MO4, Bonneville would continue funding the operations and maintenance of the LSRCP,
28404 estimated at \$34 million annually (adjusted to 2019 dollars), which is also included in the
28405 summary rate table and consistent with the No Action Alternative.

28406 **EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE**

28407 **Bonneville Interconnections**

28408 The developers of individual generation resources would have to construct certain transmission
28409 facilities (e.g., lines and equipment) to interconnect the resource to the transmission system.
28410 Those facilities would result in additional costs, which would vary depending on the location of
28411 the resource with respect to the transmission network, size of the individual project, and other
28412 factors.

28413 Bonneville, for its part of the resource interconnection, would also have to construct additional
28414 transmission facilities at the point of interconnection in order to interconnect the new resource
28415 to the transmission system. The Bonneville portion of the interconnection would require
28416 equipment such as bulk transformers, circuit breakers, and other substation equipment, which
28417 may require the expansion of multiple existing substations. The addition of transmission
28418 substation infrastructure to accommodate interconnections can take several years to plan,
28419 permit, and construct, especially at those substations requiring expansion beyond the current
28420 footprint.

28421 Based on the assumptions described above, Bonneville identified approximately \$220 million in
28422 direct costs on the transmission network (which customers would fund, and Bonneville would
28423 repay in transmission credits) necessary to accommodate the interconnection for the least-cost
28424 portfolio under MO4. Bonneville identified \$360 million in direct costs on the transmission
28425 network necessary to accommodate the interconnection for the zero-carbon portfolio under
28426 MO4. This would result in an annualized cost of \$12 million to \$19 million. The costs identified
28427 here include land and substation equipment in multiple locations near the replacement
28428 resources.

28429 **Bonneville Transmission System Reliability and Operations**

28430 Assuming that replacement resources were online by the time the changes in hydropower
28431 generation were implemented under MO4, no additional transmission reinforcements were
28432 identified beyond that in Bonneville's regular system assessments. Due to expected increases in
28433 loads in the Tri-Cities load service area, Bonneville's regular system assessments have identified
28434 several reliability projects, which are anticipated to occur within and beyond the 10-year
28435 planning horizon.

28436 Because MO4 provides for reduced generation capability, there would also be a reduction in
28437 the number of online generating units at the CRS projects of the lower Snake and lower
28438 Columbia Rivers, particularly throughout the summer at the lower Columbia CRS projects. With
28439 a reduced number of operating units and uncertainty about the characteristics of replacement
28440 resources, there may be a reduced capability to provide voltage support and dynamic stability
28441 in response to significant disturbances throughout the Western Interconnection. This could
28442 result in reduced operating limits to avoid equipment damage and potential uncontrolled loss
28443 of load. However, the assumed operating limits were not changed because there is not enough
28444 certainty about the possible replacement resources to have confidence that changing the
28445 assumptions would increase the accuracy of the studies.

28446 Operating at lower operating limits could result in increased congestion and result in redispatch
28447 of resources throughout the Western Interconnection to meet the required load demands at
28448 that time beyond that reported below under the Regional Transmission System Congestion
28449 Effects subsection. The effect on operating limits would vary based on the capability of
28450 resources online at the time and the location of those resources.

28451 Limitations around voltage and dynamic response would be aggravated under scenarios with
28452 reduced coal generation, as coal generation plants provide similar support to the system as
28453 hydropower generators. Currently, renewable resources do not currently have the technology
28454 to provide comparable dynamic and frequency support. Depending on technological
28455 development, additional transmission system requirements may be needed under a zero-
28456 carbon resource portfolio as more solar generation is brought online to replace hydropower
28457 generation. Technology under development and implementation of additional requirements
28458 may be needed under a zero-carbon resource portfolio in order to have certainty that
28459 replacement solar resources will be able to provide adequate reactive and dynamic support to

28460 respond to larger transmission disturbances. Again, these transmission reinforcements can take
28461 several years to design, permit, and construct should they be needed.

28462 **Regional Transmission System Congestion Effects**

28463 The fluctuation in the number of congestion hours under MO4 relative to the No Action
28464 Alternative would be small in comparison to the fluctuations already caused by variations
28465 between runoff conditions (i.e., differences between high, median, and low run-off conditions).
28466 For most transmission paths under MO4, congested hours would not be a substantial issue in low
28467 runoff conditions regardless of replacement resource portfolio. In median and high runoff
28468 conditions, the west-to-east paths, particularly the Hemingway to Summer Lake transmission
28469 path, would experience a reduction in congestion relative to the No Action Alternative due to
28470 decreased hydropower generation available to be sent east.

28471 Most north-to-south paths would remain relatively similar to the No Action Alternative with the
28472 exception of the Pacific DC Intertie. That path would have a larger increase in congestion as
28473 electricity is exported from the region to the south.

28474 Overall, changes in the patterns of congestion under MO4 would have a relatively small or
28475 minor impact on congestion for most Pacific Northwest transmission paths and a minor to
28476 moderate increase in congestion hours for some north-to-south paths, particularly the Pacific
28477 DC Intertie during median and high runoff conditions. There would be a minor to moderate
28478 improvement in congestion hours on some west-to-east lines, particularly the Hemingway to
28479 Summer Lake transmission path.

28480 If the assumed replacement resources are not in place when changes in hydropower generation
28481 are implemented under this alternative, the number of hours and location of congestion would
28482 change depending on which replacement resources are online at the time.

28483 Under a limited to no-coal future, if a net reduction in resource availability also were to occur in
28484 the Pacific Northwest or other regions or both due to additional coal retirements, then the
28485 effects of CRS hydropower reductions, with or without replacement resources shift from what
28486 is reported above.

28487 Detailed graphs depicting the number of hours of congestion along the individual paths under
28488 different water years appear in Appendix H.

28489 **ELECTRICITY RATE PRESSURE**

28490 **Bonneville Wholesale Power Rates**

28491 Under MO4, there would be upward Bonneville wholesale power rate pressure for all
28492 portfolios. The highest upward pressures are related to the zero-carbon portfolio, which would
28493 result in the highest average wholesale rates associated with the Bonneville contracts.
28494 Table 3-182 presents the estimated wholesale power rate under MO4 based on changes in the
28495 amount of hydropower generated and the secondary (market) sales. Should the upward rate

28496 pressure lead to rate increases (i.e., assuming Bonneville or other entities were unable to
28497 balance the additional costs), Bonneville wholesale power rates could increase by \$5.31 to
28498 \$8.76 per MWh, depending on the replacement portfolio and whether Bonneville or the region
28499 replaced the lost generation. This represents an upward rate pressure between 15.3 to 25.3
28500 percent in the average Bonneville wholesale power rate compared to No Action Alternative.
28501 Structural measure costs under MO4 would total \$46 million. Appendix H, *Power and*
28502 *Transmission*, presents detailed information on structural measure costs and the effects on
28503 wholesale power rates.

28504 Unlike MO3, cost additions for storage (batteries) were not added in MO4. Generation in the
28505 winter, in MO4, has nearly the same amount of average energy and LOLP per month as the No
28506 Action Alternative. The months when MO4 has significantly less energy and particularly less
28507 capacity for which battery storage would be useful are in the summer. But unlike MO3 where
28508 the generators at the lower Snake River projects are not available, in MO4 the possibility would
28509 exist to use the generators in a power emergency by temporarily diverting more water through
28510 the turbines instead of the spillway, if allowed.

28511 Summary results for Bonneville's wholesale power rate pressure analysis in the Bonneville
28512 Finances scenario are presented in the first section of Table 3-181. As discussed in Section
28513 3.7.3.1, the second section of Table 3-166 provides the cost pressure to the region of MO4 in
28514 light of potential carbon compliance and accelerated coal retirements.

28515 Results for the Region Finances scenario are presented in Table 3-183. It is important to note
28516 that the rate pressure presented in this table is from the perspective of Bonneville's power rate.
28517 As such, in the Region Finances scenario, replacement resource costs are assumed to be
28518 recovered by regional utilities (not Bonneville), and therefore, are excluded from Bonneville's
28519 wholesale power rates. The Socioeconomic section shows the geographic distribution of rate
28520 impacts down to retail rates in both scenarios. As such, the costs which are missing from
28521 Bonneville rates in the Region Finances scenario are included in retail rate impacts of the
28522 consortium of public customers assumed to finance the resource replacement. The summary
28523 analysis focuses on the Bonneville Finances scenario, because this includes most of the relevant
28524 costs affecting its customer base, while the Region Finances scenario excludes real costs
28525 affecting regional rates which are not explicitly included in Bonneville's wholesale power rate.

28526 **Bonneville Finances**

28527 **Table 3-182. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 4,**
28528 **for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures**
28529 **Associated with Additional Sensitivity Analysis**

Change in Bonneville's Priority Firm Rate, Bonneville Finances					
		Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
		\$ rate pressure	change from NAA	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)					
1	Base Rate	\$43.32 /MWh	\$8.76 /MWh	\$42.70 /MWh	\$8.14 /MWh
2	Change from NAA due to Costs	\$568	27.0%	\$347	17.8%
3	Change from NAA due to Load		-1.7%		5.8%
4	Total Base Change in Rate		25.3%		23.5%
Rate Sensitivities (annual cost in \$ millions)					
5	Fish and Wildlife Costs	-\$105 to \$0	-5% to 0%	-\$105 to \$0	-5.4% to 0%
6	Integration Services	\$121 to \$142	5.4% to 6.3%		
7	Resource Financing Assumptions	\$0 to \$125	0% to 5.6%	\$0 to \$33	0% to 1.6%
8	Resource Cost Uncertainties	\$0 to \$24	0% to 1.1%	\$0 to \$16	0% to 0.7%
9	Demand Response	-\$12 to \$52	-0.5% to 2.3%		
10	Oversupply	\$2 to \$4	0.1% to 0.2%	-\$4 to -\$3	-0.2% to -0.1%
11	Total Rate Sensitivities	\$6 to \$347	0.0% to 15.5%	-\$109 to \$46	-5.6% to 2.2%
12	Total Base Effect + Sensitivities	\$574 to \$915	25.3% to 40.8%	\$238 to \$393	17.9% to 25.7%
Other Regional Cost Pressure (annual cost in \$ millions)					
		Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
		\$ pressure	change from NAA	\$ pressure	change from NAA
13	Regional Cost of Carbon Compliance	\$10 to \$37		\$104 to \$561	
14	Regional Coal Retirements (capital)	\$0 to \$0			
15	Regional Coal Retirements (other)	too uncertain to estimate		too uncertain to estimate	

28530
28531 Notes: Base Rate includes the Colville settlement payment, which has a 5 to 9 percent increase from the No Action
28532 Alternative.

28533 **Base Case Analysis**

28534 Base rate pressures range from 23.5 percent to 25.3 percent depending on the resource
28535 portfolio, with slightly higher rate pressure associated with the zero-carbon resource
28536 replacement. In the zero-carbon scenario, annual average cost pressure is \$568 million per year
28537 (2019 dollars) which equate to upward pressure of 27 percent, and a small increase in
28538 preference customer loads leading to a 1.7 percent downward pressure on power rates,
28539 resulting in a 25.3 percent upward pressure on base rates. Rate pressure includes an increase in
28540 net secondary sales revenues associated with the large solar build, that is more than offset by
28541 large capital costs to finance and maintain the solar resource replacement, structural measure
28542 debt financing, and higher energy efficiency expenses associated with the demand response

28543 program. In the least-cost scenario, the \$347 million per year in upward rate pressure is
28544 associated with lower net secondary revenues, and capital, fuel and O&M costs associated with
28545 the gas turbine resource replacement, as well as structural measure debt financing (2019
28546 dollars), resulting in a 17.8 percent upward pressure on rates. In addition to these cost
28547 pressures, preference loads in the least-cost scenario are lower, contributing to a 5.8 percent
28548 upward pressure on power rates alone. Overall this results in a 23.5 percent upward pressure
28549 on base rates.

28550 Rate Sensitivity Analysis

28551 Rate sensitivities are presented in Table 3-182, lines 5 through 11 to provide quantitative
28552 estimates relative to the additional sensitivity analyses described in Section 3.7.3.1.

28553 Line 5 of the cost analysis shows that Bonneville's fish and wildlife expenses could be as much
28554 as \$105 million per year lower in MO4 than in the No Action Alternative and included in base
28555 rates, owing to higher spill and lower generation and the reduced need for mitigation efforts.

28556 For line 6, Integration Services, other than energy shaping effects between HLH and LLH
28557 periods, changes in the value of lost flexibility due to increased spill and other constraints on
28558 the FCRPS under MO4 are not explicitly included in base rates. Generation inputs revenues for
28559 contingency reserves and balancing services are assumed to be the same as the NAA. However,
28560 the ability of the FCRPS to carry generation balancing reserves is reduced under MO4. To
28561 monetize the value of changes in contingency and generation balancing reserve carrying
28562 capability, the sensitivity analysis incorporates integration costs associated with contingency
28563 and balancing needs of replacement resources.⁸²

28564 Annual resource integration costs associated with replacement resources under MO1 were
28565 calculated using BP-20 operating and generation balancing reserve rates. Estimated annual
28566 integration costs for the 5000 MW solar resource replacement under MO4 for the zero carbon
28567 portfolio ranged from \$121 million to \$142 million.

28568 Resource financing assumptions (line 7), which addresses alternative amortization periods to
28569 the 30 years assumed in base rates, shows upward cost pressure of \$125 million per year in the
28570 zero-carbon portfolio and \$33 million per year in the least-cost scenario.

28571 Resource cost uncertainties (line 8) range from upward cost pressure of \$16 to \$24 million from
28572 the base rates, depending on whether the zero-carbon or least-cost portfolio.

28573 Demand response costs (line 9) could be lower than assumed in the \$20 million/year⁸³ in base
28574 rates; a potential cost savings of \$12 million per year is shown on the low end for this
28575 sensitivity. However, to account for the challenges to scaling up demand response programs in
28576 Bonneville's service territory, this portion of the portfolio could be as high as \$52 million per

⁸² Ramping flexibility not quantified for MO1 or MO4.

⁸³ Demand Response costs in zero-carbon scenarios; \$20 million for Bonneville finances, and \$30 million for region finances).

28577 year higher than assumed in base rates if up to 50 percent of the program needed to be
28578 replaced with a 300 MW solar resource with battery technology instead

28579 OMP costs associated with oversupply events (line 10) could be \$2-4 million per year higher in
28580 the zero-carbon portfolio and a cost savings of \$3 million to \$4 million in the least-cost
28581 portfolio.

28582 Other Regional Cost Pressure

28583 Cost pressures to regional utilities, which do not necessarily impact Bonneville's power rates
28584 but could in the future, are presented in lines 13 and 14. Effects associated with regional
28585 carbon compliance laws are unknown, pending current legislation in Oregon and Washington as
28586 discussed in Section 3.7.3.1. If binding estimates effective in the future are enforced to the
28587 resource portfolio in MO4 alternative, regional utilities could face cost pressure relative to the
28588 No Action Alternative of \$10-37 million per year. In the conventional least-cost scenario, carbon
28589 enforcement costs could range between \$104 and \$561 million per year.

28590 As described in Sections 3.7.3.1, Availability of Coal Resources subsection, and 3.7.3.2, Effects
28591 on Power System Reliability subsection, regional utilities would need to add 8,800 MW of
28592 additional zero-carbon resources in the limited coal capacity scenario and 28,000 MW of
28593 additional zero-carbon resources in the no coal scenario to maintain regional LOLP at the No
28594 Action Alternative levels (6.6 percent). Lines 14 and 15 estimate the incremental zero-carbon
28595 resources costs needed by the region to maintain the No Action Alternative LOLP of at least
28596 6.6 percent under MO4 in light of a limited or no coal assumption. An "incremental zero-carbon
28597 resource cost" occurs if the combination of (1) the resources Bonneville or the region is
28598 expected to acquire under the MO, plus (2) 8,800 MW (under the limited coal scenario) or
28599 28,000 MW (under the no coal scenario), is less than the total amount of zero-carbon resources
28600 needed to return the region to the No Action Alternative LOLP of 6.6 percent.

28601 For the limited coal capacity scenario under MO4, a minimum of 12,000 MW of zero-carbon
28602 resources would need to be added to maintain regional LOLP at the No Action Alternative level
28603 of 6.6 percent. Bonneville or the region is expected to acquire 5,600 MW of zero-carbon
28604 resources under MO4 in the base case. Adding 5,600 MW to 8,800 MW exceeds the minimum
28605 12,000 MW, so this MO has no incremental cost impact on the region if a limited coal scenario
28606 is assumed. See Table 3-181.

28607 For the no coal capacity scenario under MO4, a minimum of 30,000 MW of zero-carbon
28608 resources would be needed to maintain regional LOLP at the No Action Alternative level of
28609 6.6 percent. Bonneville or the region is expected to acquire 5,600 MW of zero-carbon resources
28610 under MO4 in the base case. Adding 5,600 MW to 28,000 MW exceeds the minimum
28611 30,000 MW, so this MO has no incremental cost impact on the region if a no coal scenario is
28612 assumed. See Table 3-183.

28613 **Region Finances**

28614 Results for the Region Finances scenario are presented in Table 3-183. It is important to note
 28615 the rate pressures in this table are from the perspective of Bonneville’s wholesale power rates.
 28616 In the Region Finances scenario, replacement resource costs are excluded from Bonneville’s
 28617 wholesale rate, with those costs collected from rates charged by other entities in the region,
 28618 ultimately paid by the customers of utilities that would be receiving less power from Bonneville.
 28619 The *Socioeconomic* section below shows the geographic distribution of rate impacts down to
 28620 retail rates in both scenarios, so that these costs which are not in Bonneville rates in the Region
 28621 Finances scenario are included in retail rate impacts of the consortium of public customers
 28622 assumed to finance the resource replacement.

28623 **Table 3-183. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 4,**
 28624 **for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures**
 28625 **associated with Additional Sensitivity Analysis for the Case, Region Finances**

Change in Bonneville's Priority Firm Tier 1 Rate, Region Finances				
	Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
	\$ rate pressure	change from NAA	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)				
Base Rate	\$40.88 /MWh	\$6.32 /MWh	\$39.87 /MWh	\$5.31 /MWh
Change from NAA due to Costs	\$136	7.3%	\$83	4.4%
Change from NAA due to Load		11.0%		10.9%
Total Base Change in Rate		18.3%		15.3%

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28627 **Market Prices**

28628 The secondary market sales under MO4 would vary depending on the replacement resource.
 28629 Under MO4, the average market price would increase from \$19.42 under the No Action
 28630 Alternative to \$20.82 per MWh under the conventional least-cost portfolio and decrease to
 28631 \$19.32 per MWh under the zero-carbon portfolio. The price under MO4 would fluctuate more
 28632 over the course of the year relative to the No Action Alternative due to changes in hydropower
 28633 generation and perhaps the solar generation profile across the seasons as can be seen in
 28634 Figure 3-188, which is under the least-cost portfolio.

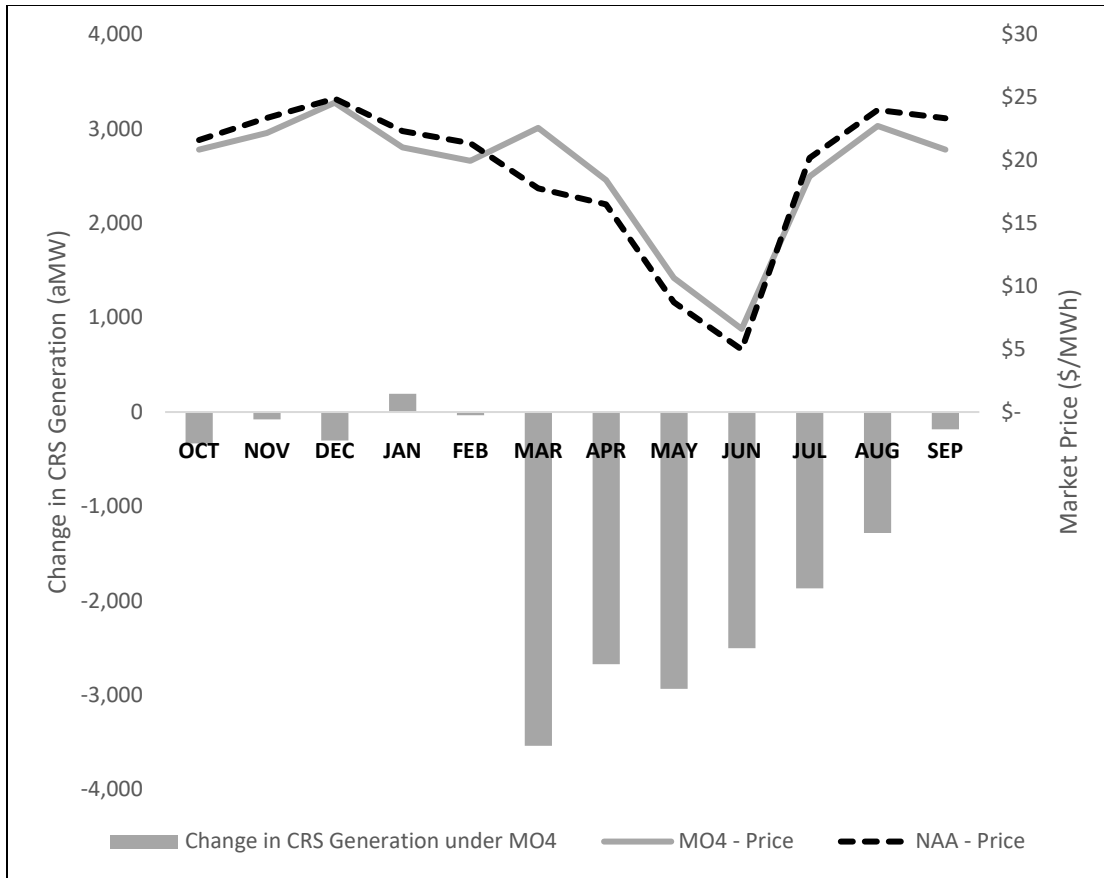


Figure 3-188. Monthly CRS Generation (aMW) and Market Price (\$/MWh) under Multiple Objective 4

Note: The right axis is the market price (\$/MWh). The left axis is generation from the CRS projects by month (aMW).

Source: Power Analysis

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Bonneville Wholesale Transmission Rate Pressure

Upward transmission rate pressures under MO4 would be about 1.6 percent annually (14 percent over an 8-year period) for the least-cost portfolio, and 1.9 percent (17 percent over an 8-year period) under the zero-carbon portfolio, relative to the No Action Alternative. Across customers and portfolios, the range of annualized upward transmission rate pressures would be from 0.72 to 4.0 percent. The capital investments associated with the interconnection of generation under the two resource-replacement portfolios drive the upward rate pressure more than the changes in short- and long-term sales (though the quantity of sales do change) under this alternative. This is because the capital investments are considerably larger costs than the changes in sales quantities.

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Retail Rate Effects

The retail rate that end users pay to their individual utilities for electricity would experience upward rate pressure under MO4 compared to the No Action Alternative. Should the upward

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28654 rate pressure lead to increases in rates, the average retail rates under MO4 would range from
28655 10.48 cents per kWh to 10.52 cents per kWh for residential end users, depending on the
28656 replacement portfolio with generally lower rates for customers whose utilities do not receive
28657 power from Bonneville and higher rates for customers of utilities receiving power from
28658 Bonneville. On average, counties would experience a 2.8 to 3.2 percent upward rate pressure
28659 effect on their residential retail rate, depending on the replacement portfolio, relative to the No
28660 Action Alternative. The largest effect for all end-user groups under MO4 is a 36 percent upward
28661 rate pressure in the industrial retail rate.

28662 **BONNEVILLE FINANCIAL ANALYSIS**

28663 As previously described, the Bonneville financial analysis considers the effects of the MOs on
28664 future cash flows over a 30-year financing period for potential replacement resources.
28665 For MO4, the discounted NPV of the cash flow effects under each resource replacement
28666 portfolio are described in Table 3-184 below. This NPV analysis is Bonneville specific and does
28667 not capture wider societal impacts. This NPV analysis uses a risk adjusted discount rate of
28668 7.9 percent and a 30-year timeframe.

28669 The sensitivities in this analysis are described in the Power Rates section, above.

28670 **Table 3-184. Bonneville Financial Analysis Results (in Millions \$2019)**

Analysis Type	MO4	
	Zero Carbon	Conventional Least- Cost
Power	-\$6,400	-\$5,031
Transmission	-\$399	-\$270
Total Base Impact – Bonneville	-\$6,799	-\$5,301

28671 **SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION**

28672 Except where noted, this section describes the base analysis for MO4 without considering the
28673 range of additional costs shown in Table 3-185 and without the retirement of additional coal-
28674 plants.

28675 **Social Welfare Effects**

28676 This social welfare analysis employs both the market price and production cost methods based
28677 on the base case for this analysis, assuming no additional coal plant retirements. Section
28678 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*, describes the differences
28679 between these two methods. Table 3-185 presents the market value of the reduction in Pacific
28680 Northwest hydropower generation under MO4 as compared with the No Action Alternative.
28681 Based on the market price method, the average annual economic effect of MO4 is a
28682 \$180 million cost. If these social welfare effects persist over a 50-year timeframe, the present
28683 value costs would be \$4.8 billion.

28684 **Table 3-185. Average Annual Social Welfare Effect of Multiple Objective 4 Based on the**
28685 **Market Price of Changes in Pacific Northwest Hydropower Generation (2019 U.S. Dollars)**

Change in Generation (aMW)	Change in Generation (MWh)	Average Annual Social Welfare Effect
-1,300	-12,000,000	-\$180,000,000

28686 Table 3-186 evaluates the social welfare effects of MO4 based on the additional costs of adding
28687 enough capacity to the system to meet power demand given the reduction in hydropower
28688 generation described in Table 3-180. Based on this approach, the social welfare effects of MO4
28689 range from an average annual cost of \$380 million (assuming a least-cost replacement resource
28690 portfolio) to \$650 million (assuming a zero-carbon replacement resource portfolio). If these
28691 social welfare effects persist over a 50-year timeframe, the present value costs would be
28692 \$10 billion to \$18 billion.

28693 **Table 3-186. Average Annual Social Welfare Effect of MO4 Based on the Increased Cost of**
28694 **Producing Power to Meet Demand (2019 U.S. Dollars)**

Production Cost Factor ^{1/}	Replacement Resource Portfolio	
	Zero Carbon	Conventional Least Cost
Annualized Fixed Cost of Replacement Resources	-\$580,000,000	-\$160,000,000
Annualized Fixed Cost of Transmission Infrastructure	-\$19,000,000	-\$12,000,000
Average Annual Variable Costs	-\$53,000,000	-\$210,000,000
Average Annual Social Welfare Cost	-\$650,000,000	-\$380,000,000

28695 Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
28696 1/ Negative values in the table represent an increase (net cost) in the cost of producing power.

28697 **Regional Economic Effects**

28698 Estimated average retail electricity rates would experience upward rate pressure under MO4
28699 with increases up to over 1 cent per kilowatt-hour in certain counties. These upward retail rate
28700 pressures may negatively affect residential, commercial, and industrial end users due to the
28701 increase in spending on electricity relative to the No Action Alternative.

28702 **Residential Effects**

28703 Examining potential residential retail rate increases on a geographic basis, the effects of MO4
28704 would negatively affect residential end users across the Pacific Northwest. Many residential end
28705 users would experience average upward rate pressure greater than 5 percent relative to the No
28706 Action Alternative—many would experience upward pressure much higher than historical year-
28707 to-year rate changes. The upward residential rate pressure under MO4 would range as high as
28708 18 percent for certain counties while some utilities that would not purchase Bonneville power
28709 could be largely isolated from the higher rate effects with some experiencing increases in rate
28710 pressure as low as 0.04 percent due to beneficial market effects. However, MO4 also could
28711 result in higher regional total production costs generating adverse rate effects on utilities that
28712 do not purchase power from Bonneville.

28713 Under MO4, the largest residential rate pressure effects would occur in small non-metropolitan
28714 urban areas, where, under the zero-carbon portfolio, average upward rate pressure effects of
28715 3.4 percent and 4.6 percent would occur in the region-financed or Bonneville-financed
28716 portfolios, respectively. Rural areas under MO4 would experience smaller rate pressure
28717 increases relative to No Action, ranging from 1.1 to 2.4 percent. By CRSO region, the effects
28718 would be concentrated in Regions A and D. Table 3-187 presents the average rate pressure
28719 increase by CRSO region. Under a zero-carbon Bonneville-financed portfolio, Region A and D
28720 would experience average increases of 3.8 percent and 5.0 percent, respectively.

28721 **Table 3-187. Average Residential Retail Rate Pressure Effect by Columbia River System**
28722 **Operating Region Under Multiple Objective 4**

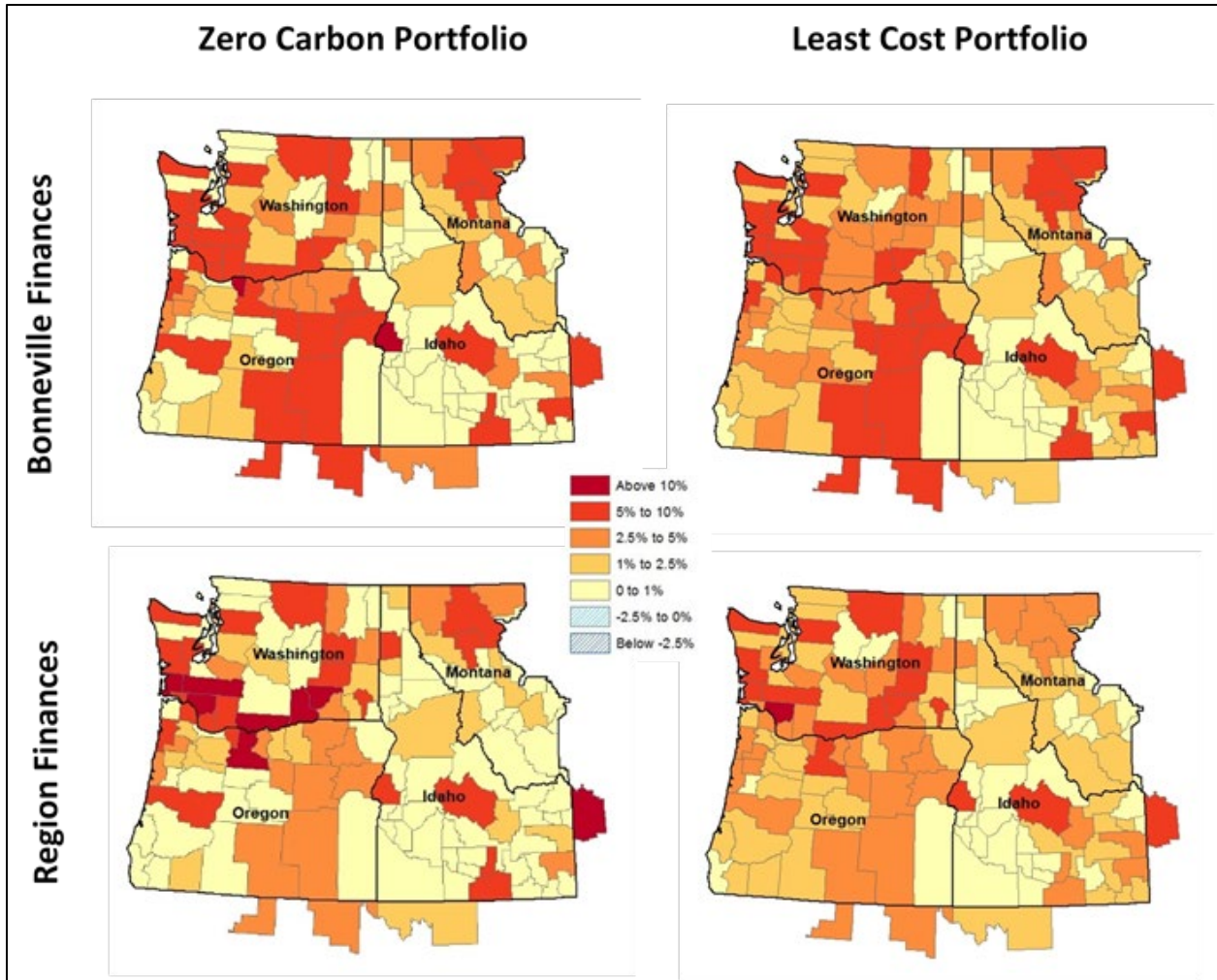
CRSO Region	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Region A	3.8%	3.4%	2.3%	2.3%
Region B	3.0%	2.9%	4.0%	3.3%
Region C	1.6%	2.0%	1.3%	1.7%
Region D	5.0%	4.6%	6.1%	4.7%
Other	2.6%	3.1%	2.4%	2.6%

28723 Figure 3-189 shows the potential residential rate pressure effects under MO4 relative to the No
28724 Action Alternative. Upward rate pressure effects would occur across the entire region with
28725 higher increases occurring under the zero-carbon portfolio due to the high replacement
28726 portfolio costs.

28727 Over time, the difference in retail rate pressure between MO4 and No Action would increase
28728 due to wholesale rate pressures. Table 3-188 presents the change in 2022 and 2041 for all end-
28729 user groups. Considerable uncertainty surrounds load and rate pressures over time, but these
28730 changes under MO4 would likely have negative effects over the long term for end user retail
28731 rates.

28732 To the extent that the upward rate pressure leads to changes in rates, end users would increase
28733 spending on electricity. Examining average expenditures, under MO4, the average residential
28734 end user would spend between \$28 and \$32 more per year on electricity. The highest effects
28735 across the Pacific Northwest would result in up to \$160 more spent per year on electricity
28736 compared to the No Action Alternative.

28737 Categorizing the number of households by expenditure effect, roughly a quarter of all
28738 households would experience increases above 5 percent in their spending under the zero-
28739 carbon Bonneville-financed portfolio MO4 relative to the No Action Alternative (Table 3-189).
28740 Under the zero-carbon Bonneville-financed portfolio, less than 1 percent of all households
28741 would experience increases above 10 percent. Under the zero-carbon portfolios, approximately
28742 a third of all households would experience a minimal change between 0 and 1 while only 12
28743 percent would experience that range under the least-cost portfolios.



28744
 28745 **Figure 3-189. Residential Electricity Rate Pressure Effects by Portfolio for Multiple Objective 4**
 28746 **for the Base Case Without Additional Coal Plant Retirements**

28747 **Table 3-188. Average Upward Retail Rate Pressure Effect in 2022 and 2041 under Multiple**
 28748 **Objective 4 Relative to the No Action Alternative**

Financing	Portfolio	Residential		Commercial		Industrial	
		2022	2041	2022	2041	2022	2041
Bonneville	Zero Carbon	2.9%	4.6%	3.0%	4.8%	4.2%	5.9%
	Conventional Least Cost	3.2%	4.6%	3.4%	4.8%	4.5%	6.0%
Region	Zero Carbon	2.9%	4.6%	3.0%	4.7%	4.2%	6.0%
	Conventional Least Cost	2.8%	4.3%	3.0%	4.5%	4.0%	5.5%

28749 These expenditures under MO4 would, on average, account for 1.737 to 1.742 percent of
 28750 household income. This represents a 0.18 to 0.31 increase in percent of income spent on
 28751 electricity relative to the No Action Alternative. The portion of income spent on electricity for

28752 some residential end users would increase by up to 10 percent, though these effects would
28753 occur in some counties with higher-than-average household incomes to begin with (e.g., an
28754 increase from 1.3 percent of income to 1.6 percent, which is already below the regional
28755 average) (Census 2016). The total increase in household spending on electricity across all Pacific
28756 Northwest households would be between \$160 million and \$180 million per year.

28757 **Table 3-189. Percentage of Residential End Users who Experience Changes in Electricity**
28758 **Expenditures by Size of Expenditure Change in each Portfolio under Multiple Objective 4**

Sector	Expenditure Change	Bonneville Finances		Region Finances	
		Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Residential	>+10%	0.17%	0%	3.9%	0.79%
	+5 to 10%	23%	20%	17%	9.5%
	+2.5 to 5 %	13%	21%	13%	26%
	+2.5% to 1%	33%	47%	29%	51%
	+0% to 1%	31%	12%	37%	12%
	Decrease	0%	0%	0%	0%

28759 Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

28760 Under MO4, expenditures and rates would increase, which would likely result in end users
28761 reducing their consumption based on the elasticity of demand. If consumption were reduced,
28762 the average household could reduce consumption and save between \$28 and \$32 per year
28763 from conservation under MO4 depending on the portfolio, partially offsetting the increase in
28764 residential rates; however, if consumption remained constant, then there would be no reduced
28765 costs (Census 2016). In counties where the increase in rates would be highest, households that
28766 decreased consumption most could reduce the cost increase by as much as \$160 per year in the
28767 highest rate increase portfolio (Bonneville-financed zero-carbon).

28768 This analysis considers how the region-wide changes in household spending on electricity would
28769 affect demand for other goods and services across the region. That is, the increased spending
28770 on electricity may reduce spending on other items, affecting regional economic productivity.
28771 This analysis applies IMPLAN to model the increased spending on electricity as a reduction in
28772 household income (direct effect), and quantifies the multiplier effects on interrelated economic
28773 sectors (indirect and induced effects). This analysis finds that the potential increased cost of
28774 household electricity could result in the loss of between \$170 million and \$190 million in
28775 regional output (sales) and between 1,100 and 1,200 jobs (Table 3-190). The majority of
28776 regional economic effects would occur Washington and Oregon.

28777 **Table 3-190. Regional Economic Effects from Changes in Household Spending on Electricity**

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Output	-\$170 million	-\$190 million	-\$170 million	-\$170 million
Value Added	-\$100 million	-\$110 million	-\$100 million	-\$100 million

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Labor Income	-\$56 million	-\$63 million	-\$56 million	-\$56 million
Employment	-1,100 jobs	-1,200 jobs	-1,100 jobs	-1,100 jobs

28778 Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional
28779 economy

28780 **Commercial and Industrial Effects**

28781 Commercial and industrial retail rates would also experience upward rate pressure under MO4
28782 with average upward rate pressure between 3.0 and 3.4 percent for commercial end users and
28783 between 4.0 and 4.5 percent for industrial end users relative to the No Action Alternative
28784 across the region. Areas with large numbers of commercial entities (King, Pierce, Snohomish,
28785 and Multnomah Counties) would continue to have relatively low rates and would experience a
28786 range of changes (5.8 percent in Pierce County, 0.93 percent in Multnomah County, and
28787 2.4 percent in King County)). The exception under MO4 is Snohomish County, where upward
28788 rate pressure would range up to range up to 9.4 under the zero-carbon Bonneville-financed
28789 portfolio because the retail utility serving that county is a Bonneville customer with limited
28790 generating resources of its own. Industrial effects follow similar patterns as commercial effects;
28791 however, the upward rate pressure effects are larger in areas with industrial entities. Pierce
28792 County would experience rate increases up to 7.1 percent and Snohomish County would
28793 experience rate pressure increases up to 12 percent under the zero-carbon Bonneville-financed
28794 portfolio. Over time, these retail rate differences would increase due to wholesale rate
28795 pressure.

28796 These upward rate pressures under MO4 could lead to increasing expenditures on electricity for
28797 commercial and industrial entities. For commercial end users, the upward rate pressure would
28798 be as high as an average of \$1,200 per year in certain counties. Given the large amount of
28799 electricity industrial end users tend to require, the total amount of electricity expenditures
28800 could increase by as much as \$25,000 per year. The highest percentage increase and dollar
28801 increase would not occur in the same county, as the largest percentage change would occur in a
28802 county with a lower base rate. The highest percentage increase would be a 34 percent increase
28803 in electricity expenditures for the highest impacted industrial end users, which could cause
28804 these end users' demand to fall between 4.1 and 34 percent, depending on the responsiveness
28805 (i.e., elasticity) of the industrial end users to changes in electricity price (EIA 2018). In addition
28806 to falling electricity use among individual businesses, large rate increases could cause industry
28807 to leave the region. Historically, the region had a large aluminum industry, but past increases in
28808 electricity prices contributed to those industries shutting down operations in the region, largely
28809 in favor of production in other countries (NW Council 2018). Additional large price increases
28810 associated with MO4 could similarly cause electricity-heavy industries to shift production out of
28811 the region.

28812 Table 3-191 presents the percentage of commercial and industrial entities that would
28813 experience a specific range of expenditure effects relative to the No Action Alternative.

28814 **Table 3-191. Percentage of Commercial and Industrial End Users Who Experience Changes in**
28815 **Electricity Expenditures by Size of Expenditure Change under Multiple Objective 4**

Sector	Expenditure Change	Bonneville Finances		Region Finances	
		Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Commercial	>+10%	4.3%	0%	4.5%	1.9%
	+5 to 10%	21%	21%	20%	13%
	+2.5 to 5 %	5.8%	36%	24%	38%
	+2.5% to 1%	35%	38%	15%	41%
	+0% to 1%	34%	6.1%	38%	6.7%
	Decrease	0%	0%	0%	0%
Industrial	>+10%	14%	12%	13%	4%
	+5 to 10%	16%	17%	15%	24%
	+2.5 to 5 %	8.7%	44%	29%	44%
	+2.5% to 1%	38%	26%	15%	26%
	+0% to 1%	23%	1.3%	29%	2.1%
	Decrease	0%	0%	0%	0%

28816 Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

28817 Under MO4, the total upward rate pressure across commercial businesses in the Pacific
28818 Northwest would be between \$51 million and \$58 million per year. This analysis uses the
28819 IMPLAN model to quantify the multiplier effects of the change in commercial sector
28820 productivity (Table 3-192). The multiplier effects reflect how the increased costs of doing
28821 business may affect demand for inputs to production across commercial businesses. This
28822 analysis finds that the increased cost of electricity to regional commercial businesses would
28823 result in the loss of between \$84 million and \$96 million in regional output (sales) per year and
28824 between 580 and 650 jobs. The majority of regional economic effects would occur Washington
28825 and Oregon.

28826 **Table 3-192. Regional Economic Effects from Changes in Commercial Business Spending on**
28827 **Electricity**

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Output	-\$84 million	-\$96 million	-\$84 million	-\$86 million
Value Added	-\$53 million	-\$60 million	-\$53 million	-\$54 million
Labor Income	-\$27 million	-\$31 million	-\$27 million	-\$27 million
Employment	- 560 jobs	-650 jobs	-560 jobs	-580 jobs

28828 Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional
28829 economy

28830 Under MO4, the total increase in spending on electricity across industrial businesses in the
28831 Pacific Northwest would be between \$190 million and \$210 million per year. Similar to the
28832 commercial spending analysis, the IMPLAN model is used to quantify the multiplier effects of
28833 the change in industrial sector productivity (Table 3-193). This analysis finds that the increased

28834 cost pressure of electricity to regional industrial businesses would result in the loss of between
28835 \$300 million and \$340 million in regional output (sales) and between 2,000 and 2,300 jobs.
28836 Again, the majority of regional economic effects would occur Washington and Oregon.

28837 **Table 3-193. Regional Economic Effects from Changes in Industrial Business Spending on**
28838 **Electricity**

Effect	Bonneville Finances		Region Finances	
	Zero Carbon	Conventional Least Cost	Zero Carbon	Conventional Least Cost
Output	-\$310 million	-\$340 million	-\$310 million	-\$300 million
Value Added	-\$190 million	-\$220 million	-\$200 million	-\$190 million
Labor Income	-\$99 million	-\$110 million	-\$99 million	-\$97 million
Employment	-2,000 jobs	-2,300 jobs	-2,000 jobs	-2,000 jobs

28839 Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional
28840 economy

28841 The effect on commercial and industrial businesses described above is predicated on the region
28842 acquiring replacement resources for the reduction in hydropower generation. If the replacement
28843 resources were not developed, there would be a large increase in risk to reliability. Power
28844 shortages might occur in about a third of the years, with some years experiencing more than one
28845 event. These power shortages (blackouts) would have substantial effects on businesses.

28846 **Other Social Effects**

28847 Under MO4, there would be large retail rate increases in multiple counties, as described above.
28848 These rate increases could lead certain end users to forego normal expenditures, even if slightly,
28849 given the increased energy burden from electricity costs. End users often forego heating and
28850 cooling as well as food purchases due to energy bills (EIA 2015). MO4 would increase the
28851 likelihood of such occurrences relative to the No Action Alternative. These instances of foregoing
28852 purchases or inadequately heating or cooling a home could have negative health effects.

28853 If replacement resources were built in the region, the LOLP would be reduced to the No Action
28854 Alternative level so there would not be additional safety concerns compared to the No Action
28855 Alternative. However, if the region (Bonneville or other regional entities) did not acquire
28856 additional resources, there would be a large increase in risk to reliability. Power shortages
28857 might occur in about a third of the years, with some years experiencing more than one event.
28858 These power shortages would lead to additional safety concerns, such as blackouts, particularly
28859 in the late summer. Safety concerns include heating and cooling, hospitals and other power-
28860 dependent medical support, lighting for safety, roads, and traffic lights. Because it can take
28861 many years to plan, site, permit, and construct new resources, the region might face this
28862 increased reliability risk after hydropower generation is reduced in MO4 until the new
28863 resources are available.

28864 **SUMMARY OF EFFECTS**

28865 Under MO4, hydropower generation would decrease by over 10 percent compared to the No
28866 Action Alternative. The FCRPS would lose over 12 percent of the firm power available for long-
28867 term, firm power sales to preference customers. The decrease in hydropower generation would
28868 increase the LOLP. If no new resources were built, the region would experience substantial
28869 power shortages in about one in every three years. To avoid the power shortages, large
28870 amounts of replacement power resources and would be necessary to bring LOLP to the No
28871 Action level. With the loss in hydropower generation and with replacement resources, upward
28872 wholesale power rate pressures would be 15 to 25 percent.

28873 The reduction in hydropower generation across the Pacific Northwest (a reduction of
28874 1,400 aMW including Federal and non-Federal projects) would result in an average annual
28875 economic cost of \$189 million when valued at the market price for the foregone power
28876 generation. However, the estimated increase in the marginal cost of producing power to meet
28877 demand based on additional average annual fixed and variable costs is \$380 million to
28878 \$650 million. If these social welfare effect persist over a 50-year timeframe, the present value
28879 costs would be up to \$18 billion. These values are estimates of the net economic effects from a
28880 national societal perspective.

28881 Regional utilities that purchase most or all of their power from Bonneville would experience
28882 larger effects than IOUs or other public utilities that do not purchase Bonneville power directly.
28883 Consequently, residential and commercial end users would experience upward retail rate
28884 pressure effects of up to 11 and 13 percent, with over a quarter of businesses experiencing over
28885 a 5 percent upward rate pressure under the highest rate-effect portfolio. In the
28886 |
28887 scenarios with limited or no coal generation in the region, the upward rate pressure
28888 associated with MO4 would likely be substantially higher (Table 3-194).

28889 The increased cost of electricity could increase the costs of living and doing business in the
28890 Pacific Northwest, resulting in regional economic impacts of \$630 million in lost output (sales)
28891 and 4,000 jobs.

28892 **Table 3-194. Summary of Effects Under Multiple Objective 4 without Additional Coal Plant**
28893 **Closures**

Effect	No Action Alternative ^{1/}	MO4 Relative to No Action
CRS Hydropower generation (aMW)	8,300	-1,300
Firm power of FCRPS (aMW)	7,100	-870
LOLP	6.6%	+23 LOLP %
Replacement resources to return LOLP to NAA level	— ^{1/}	3,240 MW natural gas or 5,000 MW solar and 600 MW demand response
Replacement resource cost to return LOLP to NAA level (annual cost)	— ^{1/}	+\$200 million or +\$580 million

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Effect	No Action Alternative^{1/}	MO4 Relative to No Action
Transmission infrastructure to return LOLP and/or transmission system reliability to NAA level (annualized reinforcement and/or interconnection cost)	— — ^{1/}	\$12 million to \$19 million
Average Bonneville wholesale power rate pressure (base analysis) Potential Range of Bonneville wholesale power rate (\$/MWh) Potential range of Bonneville wholesale power rate pressure including rate sensitivities	\$34.56	+15.3% to +25.3% \$38.87/MWh to \$43.32/MWh 17.9% to 40.8%
Annualized transmission rate pressure relative to NAA (%)	— — ^{1/}	+1.6% to +1.9%
Average annual social welfare effects (\$): market price method estimate	— —	-\$180 million
Average annual social welfare effects (\$): production cost method estimate	— — ^{2/}	-\$380 million to -\$650 million
Residential rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	10.21	+2.8% to +3.2% (+0.041% to 18%)
Commercial rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	8.89	+3.0% to +3.4% (+0.042% to +18%)
Industrial rate, weighted average and range across all scenarios (cents/kWh and % change from the No Action Alternative)	7.25	+4.0% to +4.5% (+0.51% to +36%)
Regional Economic Productivity Effects: Change in Output	— — ^{1/}	-560 million to -\$630 million
Regional Economic Productivity Effects: Change in Employment	— — ^{1/}	-3,600 jobs to -4,100 jobs
Share of households experiencing >5% increase in rates relative to NAA, highest across portfolios	— — ¹	+26%
Share of businesses with >5% increase in rates relative to NAA, highest across portfolios	— — ^{1/}	26%
Regional Cost of Carbon Compliance		\$10 to \$561 million/year

28894 Note: The estimated LOLP effect, and resulting social welfare and rate effects, rely on the best available
28895 information regarding planned coal plant retirements as of 2017 when the modeling efforts began for this analysis.
28896 Based on regional energy policy developments and expected coal-plant closures as of 2019, Section 3.7.3.1
28897 discusses the sensitivity of the results of the analysis to these assumptions.

28898 ^{1/} The analysis of the No Action Alternative for these effect categories provides a baseline against which the MOs
28899 are compared. Thus, the No Action Alternative results presented in this table describe the baseline magnitude of
28900 power and transmission values (e.g., for LOLP and rates) and the MO4 results describe the change relative to No
28901 Action. A “— —” indicates an effect category that is not relevant to the No Action Alternative because it only occurs
28902 as a result of implementing the MOs (e.g., the need for new generation and transmission infrastructure and
28903 associated costs).

28904 ^{2/} The production cost method for valuing social welfare effects of the MOs relies on information on the fixed and
28905 variable costs of replacement generation resources. These costs are not relevant to the No Action Alternative.

28906 **3.7.4 Tribal Interests**

28907 Many tribes in the study area receive electricity through Bonneville. Some have tribal utilities
 28908 that get power directly from Bonneville and some are served by public utilities that get power
 28909 from Bonneville. Therefore, any upward or downward movement in power rate pressure would
 28910 directly affect tribes. Rate discussion is included above and also in more detail in Appendix J,
 28911 *Hydropower*. MO4 would result in the greatest rate increases, followed by MO3.

28912 The Confederated Tribes of the Colville Reservation (CTCR) and the Spokane Tribe of Indians
 28913 (likely starting in 2021) receive annual payments from Bonneville as compensation for tribal
 28914 lands inundated by Lake Roosevelt. The payment is based on annual average generation
 28915 produced at Grand Coulee Dam as well as the power used to pump water to Banks Lake for
 28916 irrigation. Appendix J provides a summary of the annual values for Grand Coulee generation for
 28917 each of the MOs. Details of the monetary value are provided in Chapter 4 of Appendix H, *Power
 28918 and Transmission*. All MOs produced less generation at Grand Coulee than the No Action
 28919 Alternative, but they are relatively minor changes from the No Action Alternative averages (less
 28920 than -2.5 percent change depending on the alternative). Another driver for the calculation of
 28921 the payment is the price of power and revenue from power sales. Based on the combination of
 28922 reduced generation at Grand Coulee and changes in market prices for power, the estimated
 28923 payment would increase in MO1, MO3, and MO4, while MO2, would see a minor decrease in
 28924 the calculated payment as shown below in Table 3-195.

28925 **Table 3-195. Estimates of Percent Change in the Annual Payment to the CTCR and Spokane**
 28926 **Tribe of Indians, Relative to the No Action Alternative**

Alternative	Percent Change in Payment
MO1	0 to 1%
MO2	-2%
MO3	2 to 5%
MO4	5 to 9%

28927

28928 **3.8 AIR QUALITY AND GREENHOUSE GASES**

28929 **3.8.1 Introduction**

28930 The following sections describe existing conditions pertinent to regional air quality and
28931 greenhouse gas (GHG) emissions in the Columbia River Basin region. While air pollutants and
28932 GHGs may be emitted from similar sources, such as fossil fuel combustion, they have distinct
28933 consequences to human and environmental health. Air pollutants affect ambient air quality
28934 relatively close to their sources where they may more directly affect human and ecological
28935 health. On the other hand, GHG emissions, regardless of where they are generated, combine in
28936 the Earth's atmosphere, ultimately affecting global climate systems. Air pollutants and GHG
28937 emissions are relevant to this EIS given the potential for the action alternatives to affect the
28938 following emissions sources:

- 28939 • **Power generation:** Given variable emissions profiles of power-generating sources, changes
28940 in the fuel mix affect air pollutant and GHG emissions. For example, fossil fuel combustion
28941 generates air pollutant and GHG emissions whereas hydropower generation does not.
- 28942 • **Navigation and transportation:** Modal changes, such as tradeoffs between barge and road
28943 or rail, may affect levels of air pollutant and GHG emissions given the relative efficiencies in
28944 transporting goods and the variable emissions profiles of these different modes of
28945 transport.
- 28946 • **Construction activities:** Construction, demolition, and maintenance activities may release
28947 emissions or fugitive dust (or both) from construction vehicles and equipment use.
- 28948 • **Other emission sources:** Operational changes at reservoirs may result in particulate matter
28949 (PM) emissions from exposed sediment, as well as changes to reservoir methane emissions.

28950 **3.8.1.1 Area of Analysis**

28951 The area of analysis for air quality and GHG emissions reflects the area over which air pollutant
28952 and GHG emissions are generated from the above activities, as described in Section 3.7, *Power*
28953 *Generation and Transmission*, and Section 3.10, *Navigation and Transportation*. Construction
28954 activities and other emissions sources are focused at the CRS hydropower projects and
28955 reservoirs. Section 3.8.3 describes air quality and GHG emissions at the state level for
28956 Washington, Oregon, Idaho, and Montana. The extent to which air quality and GHG emissions
28957 are affected in each state varies by alternative and is evaluated in Section 3.8.3. Information on
28958 air quality and GHG emissions, as well as emissions reductions targets, is generally available and
28959 most relevant at state or county level. Thus, the affected environment discussion summarizes
28960 available information at state and county levels as opposed to by the four CRS regions. The
28961 environmental consequences analysis provides information at the CRS-region level, where
28962 feasible.

28963 **3.8.2 Affected Environment**

28964 This section separately describes the affected environment for air quality in the region
28965 (Section 3.8.2.1) and GHG emissions (Section 3.8.2.2).

28966 **3.8.2.1 Air Quality**

28967 Air pollutants include criteria pollutants (regulated under the Clean Air Act [CAA]), hazardous
28968 air pollutants (HAPs), and volatile organic compounds (VOCs). In the Columbia River Basin,
28969 these air pollutants are emitted by stationary point sources (e.g., industrial plants) and mobile
28970 sources (e.g., vehicular travel). The emissions in turn affect ambient air quality to which people
28971 and ecological resources are exposed.

28972 **AIR QUALITY REGULATIONS AND MANAGEMENT**

28973 Air pollutants are regulated on national, state, and local levels to protect public health and the
28974 environment. The CAA is the Federal law that regulates air emissions in the United States.
28975 Under the CAA, the U.S. Environmental Protection Agency (EPA) establishes National Ambient
28976 Air Quality Standards (NAAQS) for common pollutants. The six CAA criteria pollutants are:
28977 carbon monoxide (CO), lead, ground-level ozone (O₃), nitrogen dioxide (NO₂), particulate
28978 matter (PM_{2.5} and PM₁₀), and sulfur dioxide (SO₂) (EPA 2018a).

28979 These pollutants affect human health and the environment in different ways. For example,
28980 depending on the level of exposure, carbon monoxide can cause hypoxia; lead generates
28981 neurotoxic effects in children; NO₂, ozone, PM, and SO₂ can lead to respiratory effects. These
28982 pollutants can also adversely affect soil, vegetation, water quality, fish, and wildlife. Appendix
28983 G, *Air Quality and Greenhouse Gas Emissions*, describes sources of emissions and potential
28984 adverse effects of exposure to these criteria pollutants. The EPA establishes two types of
28985 NAAQS: primary NAAQS protect human health, including the health of sensitive
28986 subpopulations; secondary NAAQS protect public welfare, which includes protection against
28987 damage to water, soil, and adverse effects on visibility. Appendix G identifies the current
28988 NAAQS by pollutant.

28989 Individual states are responsible for developing state implementation plans (SIPs) that meet or
28990 exceed EPA NAAQS. SIPs must contain control measures for emissions that cross state lines
28991 (EPA 2013). All Pacific Northwest states have EPA-approved SIPs for meeting air quality
28992 standards.

28993 Title V of the CAA requires operating permits for all major sources of pollutants as well as a
28994 limited number of smaller sources.¹ A pollutant source may have to meet additional

¹ The Clean Air Act defines “major sources” as any stationary source or group of stationary sources that emits or has the potential to emit 10 tons per year or more of any hazardous air pollutant, or 25 tons per year or more of any combination of hazardous air pollutants (CAA Section 112a). All regional coal power plants, and nearly all regional natural gas power plants for which information is available, meet these thresholds based on the most recent EPA data (EPA 2018c).

28995 requirements as part of the CAA New Source Review (NSR) Permitting program. For new major
28996 sources of pollutants or existing sources planning major modifications, there are two types of
28997 additional permits: Non-attainment NSR permits and Prevention of Significant Deterioration
28998 (PSD) permits. Non-attainment NSR permits apply to sources located in an area that is out of
28999 attainment with the NAAQS (i.e., “nonattainment areas”). These permits are specific to each
29000 nonattainment area and require the lowest achievable emission rate, offsetting emissions, and
29001 may specify additional requirements (EPA 2016b).

29002 PSD permits apply to sources located in an area that is in attainment or unclassifiable within the
29003 NAAQS.² PSD permitting requires an air quality analysis to confirm that any new emissions will
29004 not cause or contribute to a violation of NAAQS or a PSD increment threshold, and installation
29005 of the best available control technology. In particular, PSD permits provide extra protection to
29006 Class I areas, which are defined as having special natural, scenic, recreational, or historic value
29007 in a national or regional context. Chapter G-4 of Appendix G describes EPA’s Regional Haze Rule
29008 and Class I areas in further detail, as well as providing a map of Class I areas in the Pacific
29009 Northwest. While NAAQS define a maximum allowable level of emissions, a PSD increment is
29010 the maximum increase permitted to occur relative to a baseline concentration for a given
29011 pollutant. “Significant deterioration” occurs when the amount of new criteria pollutant
29012 emissions exceeds the applicable PSD increment. Through the three permitting types, the NSR
29013 program ensures new or modified sources remain compliant with the aims of the CAA to
29014 protect air quality (EPA 2019c).

29015 In addition, the General Conformity Rule, established under Section 176(c)(4) of the CAA,
29016 ensures that the actions taken by Federal agencies do not cause or contribute to violations of
29017 the NAAQS. The EPA defines “*de minimis*” levels of criteria air pollutant emissions as thresholds
29018 (e.g., tons per year) above which a conformity determination must be performed. A conformity
29019 determination requires evaluating plans and programs to ensure a project does not negatively
29020 impact a state’s air quality control strategy nor the requirements of the CAA (EPA 2014c).

29021 Air quality in Oregon, Washington, Idaho, and Montana generally meets the NAAQS, with some
29022 exceptions for PM. Table 3-196 identifies the areas within the Columbia River Basin that do not
29023 currently meet particular NAAQS (i.e., “nonattainment areas”), as well as areas that previously
29024 did not meet standards but have since reached the standard (i.e., “maintenance areas”) (EPA
29025 2013). Currently, the only nonattainment areas in the region are for PM_{2.5} (in Oakridge County,
29026 Oregon; West Silver Valley, Idaho; and Libby, Montana), and PM₁₀ (in Lane County, Oregon; Fort
29027 Hall Indian Reservation, Idaho; and multiple counties in Montana).

² The Clean Air Act defines “unclassifiable areas” as areas that cannot be designated based on available information as meeting or not meeting the NAAQS (CAA Section 107d).

29028 **Table 3-196. Nonattainment and Maintenance Areas Within the Columbia River Basin by**
29029 **State**

Pollutant	Status	Oregon	Washington	Idaho	Montana
Carbon Monoxide (CO)	Maintenance	Portland, Eugene-Springfield, Salem	Yakima, Spokane, Vancouver	Boise-Northern Ada County	Missoula
Ozone (O ₃)	Maintenance	Portland-Vancouver, Salem	Portland-Vancouver	–	–
PM _{2.5}	Nonattainment	Oakridge	–	West Silver Valley	Libby
	Maintenance	–	–	–	–
PM ₁₀	Nonattainment	Lane County	–	Fort Hall Indian Reservation	Columbia Falls, Kalispell, Whitefish, Polson, Ronan, Libby
	Maintenance	Lake County, Eugene-Springfield, LaGrande	King County, Pierce County, Spokane County, Wallula, Yakima County	Boise-Northern Ada County, Portneuf Valley, Sandpoint, Pinehurst, Shoshone County	Thompson Falls, Missoula, Butte
Lead (Pb)	Nonattainment	–	–	–	East Helena
Sulfur Dioxide (SO ₂)	Maintenance	–	–	–	East Helena

29030 Source: EPA (2018b)

29031 Ambient air quality in the United States is often measured in terms of concentrations of various
29032 pollutants, with overall air quality reported as an index score called the Air Quality Index (AQI).
29033 The AQI is reported based on the threat to human health ranging from 0 to 500, where 301 to
29034 500 is deemed hazardous and 100 generally aligns with the NAAQS (EPA 2014).

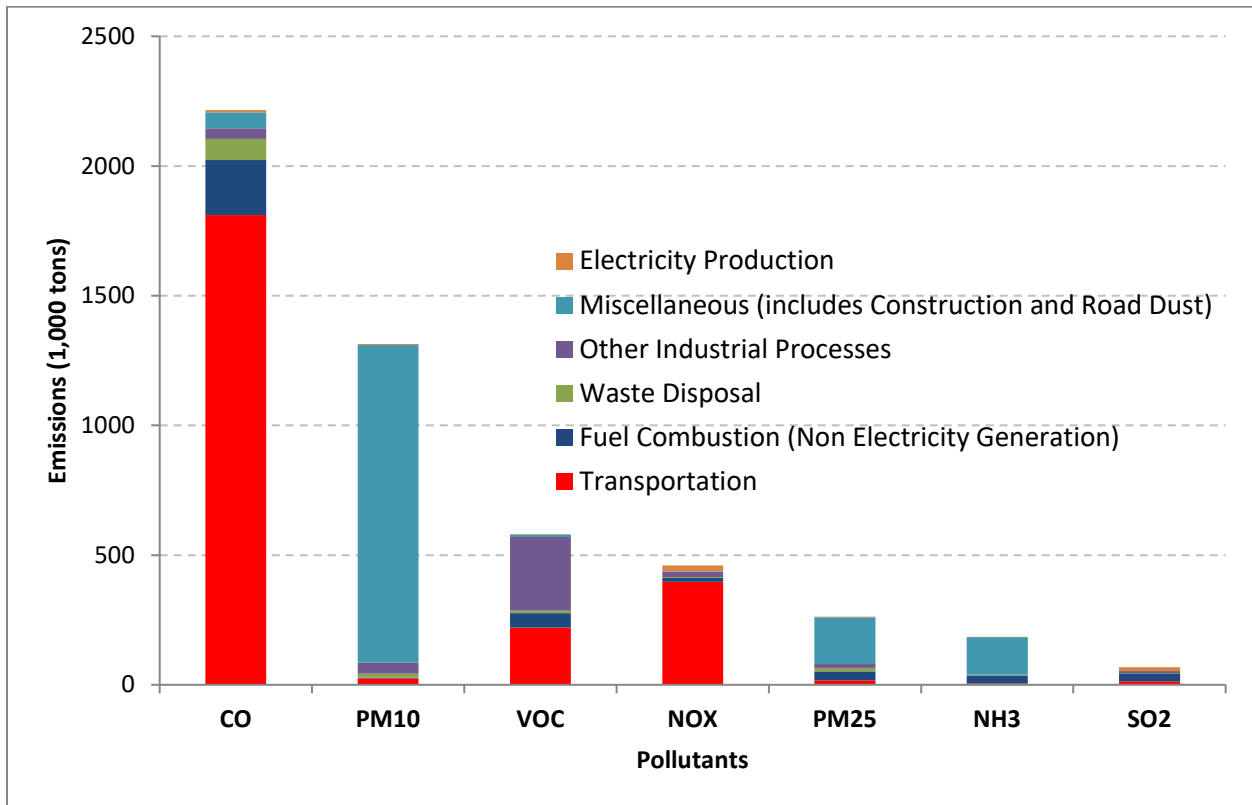
29035 All Pacific Northwest states have high rates of good air quality days relative to the national
29036 average (EPA 2018c). In the Columbia River Basin, for the year 2016, the AQI did not reach
29037 hazardous levels at all (EPA 2018c). For 89 percent of reporting days in 2016, all counties in the
29038 region reported AQI scores of zero to 50, which indicates air pollutant concentrations are
29039 generally well within the ambient air quality standards (EPA 2018c).

29040 In addition to the nonattainment and maintenance areas, the Columbia Gorge National Scenic
29041 Area is a protected natural scenic area that runs 83 miles along the Columbia River in southern
29042 Washington and northern Oregon. The National Scenic Area Act of 1986 requires the protection
29043 and improvement of resources of the Gorge. Regional haze is a key concern in this area as it
29044 creates visibility issues that affect its recreational and scenic value. Air quality studies of the
29045 Gorge Area identified on-road vehicles as a source of the regional haze (ODEQ 2011). Chapter

29046 G-4 of Appendix G describes regional haze and relevant Class I areas in further detail, along with
 29047 a map of Class I areas in the Pacific Northwest.

29048 **AIR POLLUTANT EMISSIONS LEVELS AND SOURCES**

29049 The EPA publishes the National Emissions Inventory (NEI) every 3 years to catalog emissions by
 29050 source, county, and pollutant. Emission levels of air pollutants from anthropogenic sources
 29051 from all sectors across the Pacific Northwest have remained relatively stable since 2010. In
 29052 addition to anthropogenic sources, some of the largest sources of emissions stem from natural
 29053 occurrences. Wildfires, for example, are a major cause of regional air pollutants, contributing 38
 29054 percent of regional CO emissions and 45 percent of PM_{2.5} (EPA 2018d). Regional (all of Idaho,
 29055 Montana, Oregon, and Washington) air pollutant emissions by source are shown in Figure 3-190
 29056 for each criteria pollutant and VOCs.



29057 **Figure 3-190. Regional Air Pollutant Emissions in 2016**

29058 Note: Does not include wildfires or prescribed fires.
 29059 Source: EPA (2018d)

29061 **Air Pollutant Emissions from Power Generation**

29062 As identified in Figure 3-190, electricity production in the Pacific Northwest contributes a minor
 29063 level of air pollutant emissions relative to other sources. This is because the generation of
 29064 electricity from hydropower resources does not result directly in air pollutant emissions, though
 29065 construction and maintenance of these projects have the potential to generate emissions

29066 (EPA 2018e; U.S. Energy Information Administration [EIA] 2018b). Similarly, power generation
29067 through other renewable sources, including solar and wind energy, does not contribute to air
29068 pollution. The relatively low level of criteria pollutant emissions that are associated with
29069 electricity production mainly result from fossil fuel combustion, including natural gas and coal
29070 power plants (EPA 2018f).

29071 Air pollutant emissions from power generation in the Pacific Northwest make up a much
29072 smaller share of total regional emissions than at the national level. For example, nationally,
29073 emissions of SO₂ from electricity generation account for approximately 52 percent of total SO₂
29074 emissions whereas SO₂ emission from electricity generation in the Pacific Northwest account
29075 for approximately 25 percent of all SO₂ emissions (EPA 2018d). Similarly, regional nitrogen
29076 oxides (NO_x) emissions from electricity generation account for 4 percent of total emissions, as
29077 compared with 10 percent nationally. These low levels are due to the relative prominence of
29078 hydropower-based electricity generation.

29079 ***Air Pollutant Emissions from Transportation***

29080 Mobile vehicles are segmented in the EPA NEI into on-road vehicles, locomotives, marine
29081 vessels, aircraft and non-road equipment, or vehicles or equipment (discussed below in the
29082 construction section). Excluding natural sources and wildfires, transportation is the largest
29083 source of multiple air pollutants in the Pacific Northwest (EPA 2018d). On-road vehicles account
29084 for the majority of transportation pollutants; heavy- and light-duty vehicles account for
29085 70 percent of transportation CO emissions, 66 percent of NO_x, and 60 percent of VOCs.

29086 As compared with on-road vehicles, locomotives and marine vessels in the region contribute
29087 less to the total air pollutant emissions. This difference is due to fewer ship and train miles
29088 travelled compared to passenger car and cargo trucks, as well as a higher efficiency per
29089 distance traveled in transporting either cargo or passengers as compared with on-road motor
29090 vehicles. For freight cargo, trucks carried roughly 72 percent of all cargo tons in the Pacific
29091 Northwest (Bureau of Transportation Statistics 2018). Cargo trucks emit three times as much
29092 NO_x per ton-mile³ compared to railroad and four times as much per ton-mile as compared with
29093 inland barges (0.94 grams per ton-mile compared to 0.28 and 0.21, respectively) and create six
29094 times as much PM (0.06 g/ton-mile compared to 0.01 and 0.007) (Kruse, Warner, and Olson
29095 2017). Thus, barge-based freight shipping is associated with the lowest air pollutant emissions
29096 profiles as compared with other modes of moving freight.

29097 ***Air Pollutants and Fugitive Dust from Construction or Other Operational Changes***

29098 Construction activities such as bulldozing, hauling, and construction vehicle travel generate air
29099 pollutant emissions and fugitive dust. Fugitive dust emissions from construction activities
29100 represent roughly three percent of all PM₁₀ emissions in the region (EPA 2018d). The largest

³ A ton-mile is a ton of cargo transported for a mile.

29101 sources of PM emissions in the region are unpaved road dust (29 percent of PM emissions) and
29102 crops and livestock dust (24 percent) (EPA 2018d).

29103 Exposed sediment and soils, for example due to changing reservoir levels, may also generate
29104 fugitive dust (Reclamation 2011; San Joaquin Valley Air Pollution Control District 2011).
29105 Dust from changing river or lake levels occurs when wind blows dry, exposed soils causing
29106 PM emissions (Western Regional Air Partnership 2006). The potential for dust emissions is
29107 determined by the amount of erodible soil, which can shift because of changes in hydroelectric
29108 project reservoirs exposing lake or riverbeds. Fugitive dust emissions are also dependent on the
29109 type of soil exposed, wind velocity, and temperature and precipitation (San Joaquin Valley Air
29110 Pollution Control District 2011). Dust emissions typically have localized short-term air quality
29111 effects; however, extreme events have occurred including one in Oregon in 2015, which
29112 resulted in a meteorological event 480 miles away from the lakebed source of the dust
29113 (Washington State University 2015).

29114 High-wind dust events, as defined by recent EPA Exceptional Events guidance, involve sustained
29115 wind speeds of 25 miles per hour (mph). Average wind speeds in the region are generally well
29116 below this threshold, rarely exceeding it, with variation depending on the location and season
29117 (MRCC 2018). Undisturbed areas are less likely to produce windblown dust. However, based on
29118 the EPA AP-42 emissions factors, wind erosion of unpaved roads, agricultural activities, and
29119 heavy construction operations can occur at wind speeds above 12 mph, and dust events from
29120 construction materials typically occur at above 11 mph (EPA 1995). In the Wallula Maintenance
29121 Area for PM₁₀, the most recent exceedance events all occurred when the maximum 1-hour
29122 wind speed was above 29 miles per hour with a maximum speed of 55.7 miles per hour
29123 occurring in one instance (Ecology 2019). Appendix G provides more information on wind
29124 speeds and frequencies for a variety of regional monitoring sites.

29125 ***Volatile Organic Compound and Hazardous Air Pollutant Emissions***

29126 VOCs are carbon-containing compounds such as propane, butane, and formaldehyde. VOCs
29127 form ground-level ozone by reacting with pollutants such as NO_x and CO in the presence of
29128 sunlight (EPA 2017a). Ground-level ozone is a primary ingredient in “smog” and can cause or
29129 worsen a variety of respiratory health issues, including airway inflammation, coughing, asthma
29130 and bronchitis (EPA 2017a). VOC emissions in the Pacific Northwest are primarily generated by
29131 wildfires and other biogenic sources such as vegetation and soils. These sources account for
29132 88 percent of VOCs in the region. The largest single anthropogenic source of VOCs in the Pacific
29133 Northwest was mobile vehicles, emitting about 5 percent of the total VOCs for the region (EPA
29134 2017b).

29135 There are 187 HAPs regulated by the EPA, including benzene, asbestos, and mercury
29136 compounds (EPA 2017c). People exposed to HAPs may experience increased risks of serious
29137 health effects, including cancer, immune system damage, and respiratory and neurological
29138 effects. Regional emissions of HAPs are primarily (87 percent) from biogenic sources
29139 (vegetation and soils) and fires (EPA 2017b). The largest anthropogenic source of HAPs is light-
29140 duty vehicles, emitting 4 percent of all HAPs in the Pacific Northwest (EPA 2017b).

29141 **3.8.2.2 Greenhouse Gas Emissions**

29142 GHGs trap heat in the Earth's atmosphere, contributing to the warming of the planet and
29143 shifting climate patterns. Some GHGs occur naturally in the atmosphere, such as water vapor,
29144 carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), though human activities (such as
29145 the burning of fossil fuels for energy) increase their abundance. Other GHGs, such as
29146 fluorocarbons, are synthetic. GHGs are often measured in terms of their relative global
29147 warming potential (GWP). GWP communicates the relative contribution of a unit of a particular
29148 GHG to climate change. It is a measure of the radiative forcing of a GHG relative to CO₂
29149 (Intergovernmental Panel on Climate Change 2014).⁴

29150 Multiplying an amount of a GHG by its GWP allows for emissions to be expressed in terms of
29151 carbon dioxide equivalent (CO₂e). This calculation allows for comparison in like terms of the
29152 relative effects of various GHG emissions. It also allows for emissions of multiple types of GHGs
29153 to be summed and expressed in total.

29154 While global climate change has regional impacts in the Pacific Northwest, the objective of GHG
29155 emissions reduction targets is to broadly reduce global GHG concentrations. At a national level,
29156 the primary source of GHG emissions is fossil fuel combustion for electricity generation and
29157 transportation. However, due to the prevalence of hydropower in the Pacific Northwest,
29158 regional GHG emissions from electric power generation are relatively low compared to the rest
29159 of the nation. This EIS focuses in particular on emissions from power generation and
29160 transportation sources because of the relevance of these activities to operations and
29161 management of Columbia River System projects. Chapter 4, *Climate*, includes discussion of the
29162 impacts of climate change.

29163 **GREENHOUSE GAS EMISSIONS REGULATIONS AND MANAGEMENT**

29164 There are no Federal regulations specifically focused on GHG emissions from power generation,
29165 although the EPA regulates certain GHG emission sources under the CAA.⁵ Specifically, the EPA
29166 and the National Highway Traffic Safety Administration regulate the fuel efficiencies of light-
29167 duty vehicles (passenger cars and small trucks) via the Corporate Average Fuel Economy
29168 standards (EPA 2018h). GHG emissions are managed at state and local levels, however, via
29169 emissions reductions targets and sector-specific plans and policies.

⁴ Radiative forcing properties of GHGs are due to their absorption and reflection of infrared radiation back to the Earth's surface. The GWP of CO₂ is one and GWPs of non-CO₂ GHGs are calculated relative to that of CO₂ (EPA 2018g). The GWP of CH₄ ranges from 28 to 34; for NO_x is 265 to 298. Some fluorinated gases have GWPs in the thousands. The range in GWPs relates to uncertainty regarding climate carbon feedback, which is the effect that changing climate has on the carbon lifecycle (EPA 2018g). As described by their relative GWPs, GHGs vary in their radiative intensity. Some GHGs persist longer in the atmosphere than others and some have more of a radiative effect (EPA 2018g).

⁵ On June 19, 2019, the EPA finalized the Affordable Clean Energy Rule. This rule would establish emission guidelines for states to develop plans to address greenhouse gas emissions from existing coal-fired power plants (83 FR 44746).

29170 **State and Local Level Greenhouse Gas Emissions Reductions Targets**

29171 Most Pacific Northwest states have set targets for reducing GHG emissions through regulatory,
29172 legislative, and public action. Despite relatively small emissions profiles compared to national
29173 averages, the emissions reduction targets set forth by state and local governments in the Pacific
29174 Northwest constitute considerable reductions in emissions by 2050 relative to 1990, as
29175 described in Table 3-197. The exception is Idaho, which has not identified emissions reduction
29176 targets at the state level. Both Oregon and Washington are members of the U.S. Climate
29177 Alliance, a bipartisan coalition of 23 governors (as of March 2019) committed to reducing GHG
29178 emissions consistent with the goals of the Paris Agreement.⁶

29179 **Washington Emissions Reduction Targets**

29180 Washington statewide GHG emission reduction targets commit Washington to reduce
29181 statewide emissions to 1990 levels by 2020 and to 25 percent below 1990 levels by 2035
29182 (Washington State Legislature 2007). In 2016, the Washington Department of Ecology (Ecology)
29183 adopted the Clean Air Rule, which regulates carbon by placing a cap on emissions from large
29184 sources in the state (Ecology 2016). A March 2018 court ruling, however, suspended
29185 implementation of the Clean Air Rule pending review by the Washington Supreme Court
29186 (Ecology 2018).

29187 In 2019, the Washington legislature passed the Clean Energy Transformation Act (Senate Bill
29188 5116), which is focused on limiting GHG emissions from electricity consumption in Washington
29189 and targets emissions-free electricity by 2045. By 2025, the legislation prescribes that no coal
29190 costs can be included in utility retail rates (except decommissioning and remediation) and,
29191 beginning in 2030, requires that 80 percent of electricity sold by utilities comes from carbon-
29192 free source. The legislation requires that by 2045, 100 percent of the electricity supplied by
29193 utilities in Washington should be carbon-free.

29194 **Oregon Emissions Reduction Targets**

29195 The Oregon Legislature set a state target of reducing GHG emissions to 10 percent below 1990
29196 levels by 2020 and 75 percent below 1990 levels by 2050 (House Bill 3543). In 2018, the Oregon
29197 Global Warming Commission's report to the legislature found that Oregon's GHG goals were
29198 not likely to be met with existing and currently planned actions in large part due to rising
29199 transportation-related emissions, despite having met its 2010 target (Oregon Global Warming
29200 Commission 2018).

29201 **Montana Emissions Reduction Targets**

29202 The state of Montana Department of Environmental Quality (MDEQ) published a Climate
29203 Change Action Plan in 2007 that outlined recommendations to reduce CO₂e emissions to 1990
29204 levels by 2020 (MDEQ 2007a). No state regulations have been passed related to these goals
29205 outlined in the Climate Change Action Plan.

⁶ The Paris Agreement, developed in 2015 and entered into force in 2016, is an international agreement within the United Nations Framework Convention on Climate Change to increase investment to both combat climate change and adapt to its effects.

29206 ***Idaho Emissions Reduction Targets***

29207 The state of Idaho has not announced an emissions reduction target; however, Idaho Power,
29208 the largest utility in the state, has set a goal of providing 100 percent clean energy by 2045.
29209 Another large utility, Avista, set a goal of being 100 percent carbon neutral by 2027 and 100
29210 percent carbon-free by 2045.

29211 **Table 3-197. State Greenhouse Gas Emissions Reductions Targets**

State	Bill/Plan (Year)	Accounting Method ^{1/}	Targeted Industries	Baseline Year	Emissions Reduction Targets	Source of Policy and Targets
WA	Senate Bill 6001 (2007)	Production	Fossil fuel; waste; agriculture; industrial; electricity; residential/commercial/industrial	1990	>0% by 2020 25% by 2035 70% by 2050	Senate Bill 6001 and Washington GHG Emissions Inventory, 2016
	Senate Bill 5116 (2019)	Consumption	Electricity	N/A	80% emissions-free by 2030 100% by 2045 for electricity	Senate Bill 5116, 2019
OR	House Bill 3543 (2007)	Production	Transportation; residential; commercial; industrial; agriculture	1990	Arrest growth by 2010 10% by 2020 75% by 2050	Oregon Revised Statute (2017) and Oregon Strategy for GHG Reductions, 2004
MT	Montana Climate Change Action Plan (2007)	Production, Consumption	Energy; residential/ commercial/industrial/ institutional; Transportation and land use; agriculture, forestry, and waste management	1990	Reach 1990 levels by 2020 (<i>Goals not codified</i>)	Montana Climate Change Action Plan, 2007
ID	No plan in place					

29212 1/ Production-based inventory measures GHG produced from activities within administrative boundaries whereas consumption-based emissions inventory
29213 measures GHG emitted in the production of goods (both within and outside of the administrative boundary) consumed within administrative boundaries.

29214 **Local Emissions Reduction Targets – Municipalities and Counties**

29215 Many Pacific Northwest cities and counties have also established targets for reducing GHG
29216 emissions. Three Montana mayors, 3 Idaho mayors, 13 Oregon mayors, and 11 Washington
29217 mayors are members of the Climate Mayors organization. Seattle and Portland are also
29218 members of the C40 cities, which is a network of global cities coordinating climate policy
29219 initiatives.

29220 The City of Portland met its 2013 target of reducing emissions to 14 percent below 1990 levels
29221 (Multnomah County 2017), and has a goal of 80 percent reduction from 1990 levels by 2050.
29222 The cities of Eugene and Milwaukie in Oregon have goals to become carbon neutral by 2050
29223 (Oregon Department of Energy 2018). King County, Washington’s largest county, set emission
29224 reduction targets through a county-level climate action plan (King County 2015). Located in
29225 King County, Seattle’s emissions reduction goals include being carbon neutral by 2050 (Seattle
29226 Office of Sustainability and Environment 2013). Appendix G includes a summary of county- and
29227 city-specific GHG emissions reductions initiatives.

29228 **STATE RENEWABLE ENERGY TARGETS**

29229 Oregon, Washington, and Montana have established renewable energy programs to promote
29230 growth in renewable energy sources. Renewable Portfolio Standards (RPS) require certain
29231 electric utilities to source a minimum percentage of the electricity sold to retail customers from
29232 eligible sources of renewable generation, such as solar or wind. These standards help increase
29233 the deployment of renewable power, and thus reduce emissions if they offset or replace
29234 electricity from GHG-emitting resources, such as a coal power plant.

29235 RPS programs, which are designed to be forward-looking, generally do not allow older
29236 generating facilities, including existing hydropower, to be eligible. Many states, including
29237 Oregon and Washington, do allow incremental generation from efficiency upgrades at legacy
29238 hydropower facilities to qualify for RPS programs. The Western Renewable Energy Generation
29239 Identification System is the tracking system Western states use for all RPS-eligible renewable
29240 energy certificates (RECs) generated within the region. RECs are environmental commodities
29241 used to track the production and consumption of renewable electricity and its related
29242 attributes. Utilities use RECs to demonstrate compliance with RPSs as a REC represents
29243 1 megawatt hour (MWh) of renewable electricity generated and delivered to the grid.

29244 Table 3-198 summarizes the current level of renewable power (both with and without
29245 hydropower), as well as the current targets. The region is above the national average in terms
29246 of electricity generation from renewable sources. As previously described, not all hydropower is
29247 RPS eligible.

29248 **Table 3-198. Percent of Electricity Produced from Renewable Sources and Hydropower, and**
29249 **RPS Renewable Energy Targets**

State	Percent Renewable Including all Hydropower (%)	Percent Renewable Excluding all Hydropower (%)	Renewable Energy Target (%) and Year
Idaho	78.2	20.5	N/A
Montana	44.1	7.8	15% (2015)
Oregon	71.3	13.9	25% (2025) 50% (2040)
Washington	77.5	8.8	15% (2020) ^{1/}
National	14.9	8.4	N/A

29250 Note: Data is only utility-scale generation (i.e., rooftop solar is not included). Some fraction of hydropower
29251 generation is RPS renewable; however, data is not available to describe the specific fraction that is eligible in each
29252 state.

29253 1/ As noted in Section 1.2.1.1, the Washington Clean Energy Transformation Act, passed in 2019, specifies
29254 additional targets, including 100 percent renewable and non-emitting electricity by 2045.

29255 Source: EIA (2017b); National Conference of State Legislatures (2018)

29256 **NATIONAL GREENHOUSE GAS EMISSION LEVELS AND SOURCES**

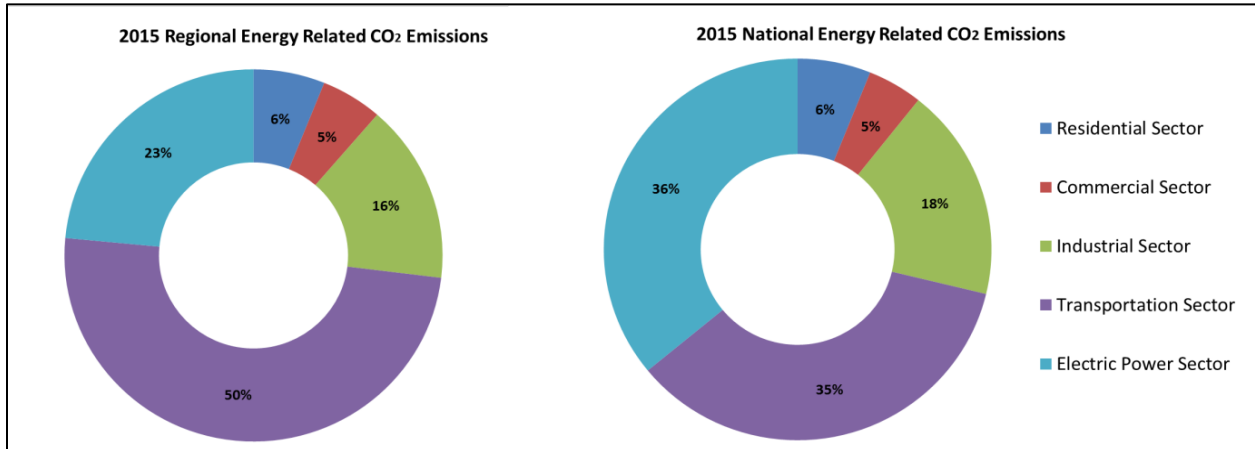
29257 This section describes various national and state GHG emissions inventories and the different
29258 sectors that generate GHG emissions. Multiple entities catalog and create inventories of GHG
29259 emissions by state and source as a means to benchmark and track progress toward emissions
29260 reductions goals. The EPA manages the Inventory of U.S. Greenhouse Gas Emissions and Sinks
29261 (EPA GHG Inventory) and the Greenhouse Gas Reporting Program to track GHG emissions at the
29262 state and national level. Together, these inventories provide an overview of United States GHG
29263 emissions. Nationally, a larger portion of GHG emissions are from electricity generation, and a
29264 lesser portion from transportation, as compared to the Pacific Northwest.

29265 **Greenhouse Gas Emissions from Energy**

29266 The EIA is a rich source of GHG emissions data associated with fossil fuel consumption and
29267 electric power generation and provides historical data that can be used to compare the
29268 country, states, and regions. The EIA calculates emissions from electric power generated within
29269 a state, not consumed within a state, as well as calculating emissions across consistent sectors
29270 in all states. The EIA calculates CO₂ emissions from the direct use of fossil fuels (e.g., residential
29271 gas heating) and primary fuels used for electricity production to the following “energy
29272 consuming” end user sources: commercial, electric power, industrial, residential, and
29273 transportation (EIA 2018c).

29274 The EIA generally reports state-level energy-related emissions just for CO₂ and not for other
29275 GHGs. EIA describes that, “because energy-related carbon dioxide (CO₂) constitutes over
29276 80 percent of total emissions, the state energy-related CO₂ emission levels provide a good
29277 indicator of the relative contribution of individual states to total greenhouse gas emissions”
29278 (EIA 2018c). Accordingly, this discussion of GHG emissions from fossil fuel consumption and
29279 electric power generation is specific to CO₂ emissions.

29280 Considered by sector, there are few changes over the last 15 years in CO₂ emissions from
29281 energy-consuming sectors in the Pacific Northwest (all of Idaho, Montana, Oregon, and
29282 Washington). The transportation sector accounts for the largest share (50 percent in 2015)
29283 of total CO₂ emissions from energy-consuming sectors. In contrast, at the national level, the
29284 electric power sector is the highest emitting sector at 36 percent (EIA 2018b).⁷ Figure 3-191
29285 shows the breakdown of Pacific Northwest and national energy-related emissions by sector.



29286
29287 **Figure 3-191. Energy-Related CO₂ Emissions by Sector**

29288 Source: EIA (2018b)

29289 Given that economic activity and population influence total emission levels, it is useful to
29290 compare regional, state, and national emissions on a per-unit level. Comparing the region's CO₂
29291 emissions per-capita or per-unit of economic output provides insight about the effects of net
29292 population migration and economic activity on the states' absolute (total) emissions numbers
29293 and demonstrates the relatively low emissions profile of the Pacific Northwest in comparison to
29294 the nation as a whole. States in the region have both low carbon intensities and low per-capita
29295 emissions based on EIA data, with the exception of Montana, which ranks above the national
29296 average in both measures. Per capita emissions, as well as the carbon intensity of the economy,
29297 are listed in Table 3-199.⁸ The table includes the Pacific Northwest states and the national
29298 average for comparison. For both measures, the relative rank among states is listed, as well as
29299 the change over the last 15 years. Montana's per capita emissions are higher than the other
29300 states within the Pacific Northwest due to a larger portion of its electricity coming from coal
29301 power plants. Montana has one of the highest per-capita emissions in the country (EIA 2018c).

⁷ As of July 2019, the EPA GHG inventory identifies the transportation sector as the largest source of GHG emissions nationally.

⁸ Carbon intensity of an economy is defined as "[t]he amount of carbon by weight emitted per unit of economic activity. It is most commonly applied to the economy as a whole, where output is measured as the gross domestic product" (EIA 2018c). Carbon intensities provide emissions per dollar of economic output, rather than per person.

29302 **Table 3-199. Energy-Related Per-Capita Emissions and Carbon Intensity**

State	Carbon Intensity 2015	State Ranking Intensity	Change (2000 to 2015)	Per Capita Emissions 2015	State Ranking per Capita	Change (2000 to 2015)
Washington	189	7	-32.6%	10.6	10	-24.9%
Oregon	189	8	-39.9%	9.5	4	-21.7%
Idaho	303	15	-12.3%	10.8	11	-10.8%
Montana	786	47	-27.8%	31.2	46	-10.2%
National Average	320	N/A	-31.3%	16.4	N/A	-21.1%

29303 Note: Carbon intensity is a ratio of grams of CO₂ emitted per dollar unit of gross domestic product. Per-capita
 29304 emissions are expressed in metric tons per person. The state rankings identify the relative carbon intensity and per
 29305 capita emissions across all 50 states, with 1 identifying the lowest levels.
 29306 Source: EIA (2018b)

29307 **State-Level Greenhouse Gas Emissions Inventories**

29308 Another way to compare emissions is a consumption-based perspective, which is generally used
 29309 for electricity and certain other sectors in state inventories, as opposed to the location where
 29310 the emissions are generated (i.e., “production-based”), as described above for the EIA and EPA
 29311 data. States often create GHG emission inventories to set emissions reductions goals, establish
 29312 baselines, and catalog their emissions levels by sector and over time. Based on various GHG
 29313 inventories, emissions in the Pacific Northwest are generally low compared to other states and
 29314 national averages (EIA 2018d). This is in large part because of the abundance of hydropower in
 29315 the region, which does not create GHG emissions when generating power (EIA 2017b). As such,
 29316 electric power generation is not the largest GHG-emitting sector in the region as it is nationally.

29317 Transportation accounts for the greatest share of GHG emissions in Idaho, Oregon, and
 29318 Washington. Electric power generation is, however, associated with the greatest share of
 29319 emissions in Montana where coal generation is relatively prominent (EIA 2018c). Each Pacific
 29320 Northwest state has developed at least one GHG emissions inventory, which are described
 29321 below. The state inventories described below use consumption-based accounting for the
 29322 electricity sector, meaning electricity use is calculated based on where the electricity is
 29323 consumed, not produced.

29324 ***Oregon and Washington Inventories***

29325 Oregon and Washington inventories report GHG emissions, most recently in 2017 and 2013,
 29326 respectively. Both inventories are created by state environmental agencies and evaluate
 29327 multiple GHGs, which are then converted to CO₂e for comparison by sector.

29328 Oregon’s total GHG emissions have declined from 70 million metric tons of CO₂e (MMT CO₂e) in
 29329 2000 to 65 MMT CO₂e in 2017 (Oregon Department of Environmental Quality [ODEQ] 2018a).
 29330 In 2016, transportation (39 percent) and electricity use (26 percent) together account for the
 29331 majority of emissions (ODEQ 2018a). Transportation emissions have stayed constant in Oregon

29332 at or around 24 MMT CO₂e since 2000, while electricity emissions fluctuated but have declined
29333 to about 16 MMT CO₂e from 23 MMT CO₂e since 2000.

29334 In Washington, emissions were highest in 2000 at 110 MMT CO₂e but have remained between
29335 90 and 100 MMT CO₂e for the last decade (Ecology 2016). In 2013, transportation (43 percent)
29336 and electricity use (19 percent) accounted for the majority of emissions (Ecology 2016).
29337 Emissions from other sectors (e.g., agriculture, industrial processes) have remained relatively
29338 constant in both Oregon and Washington (Ecology 2016; ODEQ 2018a).

29339 **Idaho and Montana Inventories**

29340 Idaho and Montana have GHG emissions inventories for the years from 1990 to 2005 with
29341 projections until 2020. In 2005, Idaho's total emissions were measured at 37.2 MMT CO₂e; the
29342 largest sector was transportation at 10.2 MMT CO₂e, or 27 percent of emissions (IDEQ 2008).
29343 Electricity emissions totaled 6.4 MMT CO₂e with 5.5 CO₂e coming from imported electricity.
29344 In Montana, the 2005 GHG inventory listed emissions of 36.8 MMT CO₂e in 2005 (MDEQ
29345 2007b). The largest emitting sector was the electric sector at 10 MMT CO₂e, accounting for
29346 27 percent of emissions; nearly all of the Montana electric sector emissions are from coal
29347 generation (MDEQ 2007b). Montana also exported electricity that accounted for another
29348 9.4 MMT CO₂e, not considered in the Montana total. In both Idaho and Montana, emissions
29349 increased from 1990 to 2000 with the largest increases coming from transportation.

29350 **Electricity Sector Greenhouse Gas Emissions**

29351 The region has historically relied on hydroelectric power and fossil-fuel fired resources for most
29352 of its electric generation. Electricity production across the Pacific Northwest region produced
29353 35 MMT CO₂e in 2016. On average, the CO₂e emission rate for coal power plants in the Pacific
29354 Northwest is 1,082 kg CO₂e/MWh, natural gas is 412 kg CO₂e/MWh, while the emissions rate
29355 for hydropower is 0 (EPA 2018e). Accordingly, emissions from electric power generation in the
29356 Pacific Northwest tend to fluctuate with the level of hydropower generation with years of poor
29357 water conditions leading to higher rates of emissions because fossil-fuel fired resources
29358 increase generation to make up for the decrease in hydropower generation (Herrera-Estrade et
29359 al. 2018).

29360 At a national level, the average MWh of electricity produces roughly 450 kg CO₂e. In the Pacific
29361 Northwest, the average is as low as 85 kg CO₂e/MWh in Idaho and Washington and 139 kg
29362 CO₂e/MWh in Oregon. As discussed for the specific inventories, states with higher use of coal,
29363 such as Montana (average emissions of 571 kg CO₂e/MWh), have higher emissions from
29364 electricity production. States with higher use of hydropower and other low-carbon resources
29365 have lower emissions per MWh as can be seen in Idaho, Oregon, and Washington. Similarly,
29366 individual utilities vary in their use of various power generation resources and therefore have
29367 variable GHG emission profiles.

29368 **Transportation Sector Greenhouse Gas Emissions**

29369 As described above, the transportation sector is a major source of GHG emissions in the
29370 Pacific Northwest. Mobile vehicles including on-road vehicles, locomotives, marine and on-river
29371 vessels, and aircraft use a variety of fuels with varying GHG emission profiles. Generally, on-
29372 road vehicle gasoline is the largest contributor to transportation GHG emissions (Ecology 2016;
29373 ODEQ 2018). Diesel fuels, which can be used in heavy-duty trucks as well as locomotives and
29374 marine vessels, are the second largest contributor. For example, in the most recent Washington
29375 inventory, on-road gasoline and diesel vehicles emitted 28.72 MMT CO₂e compared to 3.36
29376 MMT CO₂e for marine vessels and 0.86 MMT CO₂e for rail (Ecology 2016).

29377 As compared with on-road vehicles, locomotives and marine vessels in the region contribute
29378 less to total GHG emissions. This difference is due to fewer ship and train miles travelled
29379 compared to passenger car and cargo trucks, as well as a higher efficiency per distance traveled
29380 in transporting either cargo or passengers as compared with on-road motor vehicles. Cargo
29381 trucks emit 7 times as much CO₂ per ton-mile compared to railroad and 10 times as much per
29382 ton-mile as compared with inland barges (154 grams per ton-mile compared to 21.2 and 15.6,
29383 respectively) (Kruse, Warner, and Olson 2017). Barge-based freight shipping is associated with
29384 the lowest GHG emissions profiles as compared with other modes of moving freight.

29385 **Reservoir Methane Emissions from Hydropower Projects**

29386 While hydropower-based power generation does not itself emit GHGs, GHG emissions are
29387 associated with hydropower construction and maintenance activities (e.g., use of vehicles and
29388 equipment). A recent publication by Deemer et al. (2016), which evaluated global reservoir
29389 data, states that artificial reservoirs created by dams can create substantial GHG emissions.
29390 Deemer et. al. describe that reservoirs result in flooding of large areas with organic matter that
29391 decomposes, consume oxygen, and convert the organic biomass to CO₂, CH₄, and NO_x. If
29392 sufficient biomass and nutrients are available, natural breakdown of these substances can
29393 create an anoxic condition favorable to methane production.

29394 Methane emissions from reservoirs take two dominant forms. During drawdown, emissions of
29395 methane can occur during degassing (diffusion) at turbines and spillways (Deemer et al. 2016).
29396 Drops in hydrostatic pressure during water level drawdowns can also enhance methane
29397 bubbling (ebullition) because decreased hydrostatic pressure enables bubbles to move upward
29398 easily and faster (Maeck, Hofmann, and Lorke 2014). In deeper water, less ebullition occurs
29399 because the bubbles are absorbed before reaching the air (Beaulieu et al. 2016; Falter 2017).
29400 Across studies in temperate zones, recorded methane emissions from ebullition are generally
29401 greater than recorded methane emissions from diffusion (e.g., Arntzen et al. 2013; Beaulieu et
29402 al. 2016, 2018). Across two eastern Washington reservoirs specifically, ebullition accounted for
29403 over 97 percent of methane emissions from the systems studied (Miller et al. 2017).

29404 Conditions that promote methane emissions have been studied across reservoir sites. In
29405 general, methanogenesis depends on the availability of organic matter, which is then reduced
29406 under anaerobic conditions. Recent studies have associated CH₄ production with shallow depth

29407 systems, shallow (littoral) areas of reservoir systems, marshlands, embayments (coves), and
29408 stream deltas, which provide concentration points for organic matter and can positively
29409 influence methanogenesis (Bastviken et al. 2004; Demarty and Bastien 2011; West et al. 2012;
29410 Arntzen et al. 2013; Deemer et al. 2016; Falter 2017). Additionally, influx of organic and
29411 nutrient-rich material from urban and agricultural areas can cause additional decomposition
29412 and subsequent GHG emissions.

29413 Reservoir characteristics and management practices can also influence methane emissions.
29414 Among others, Deemer et al. (2016) notes the many characteristics of reservoirs that have
29415 been linked to the amount of methane emissions. These include age of the system, surface
29416 area, shoreline development, hydraulic retention time, lake level fluctuation, water circulation,
29417 winter ice cover, stratification, water temperature and transparency, etc. (see Appendix G for
29418 more detail on this factors). A recent study by Harrison et al. (2017) reviewed data for six Pacific
29419 Northwest reservoirs, identifying that reservoir drawdown affects the amount and timing of
29420 methane emissions. A global study by Ocko and Hamburg (2019) finds that the ratio of reservoir
29421 surface area to electricity generation, maximum temperature of the reservoir, and erosion rate of
29422 the reservoir are among the three best proxies for greenhouse gas emission potential.

29423 Historically, estimating methane emissions at reservoirs has been challenging due to spatial and
29424 temporal heterogeneity. More recently, promising new measurement techniques provide more
29425 sophisticated options for capturing this variability (e.g., Beaulieu et al. 2016). However, limited
29426 application of these and other techniques to gather data to date hinders the ability to estimate
29427 methane emissions at each project site.

29428 The literature identifies substantial methane emissions from hydropower projects in tropical
29429 climates, where a variety of factors, such as temperature, organic matter, and geology,
29430 generate higher emissions (St. Louis et al. 2000; Demarty and Bastien 2011). Additionally,
29431 recent studies at temperate reservoir sites, including in the United States and Europe, have
29432 shown non-negligible methane emissions levels, particularly from ebullition (e.g., Arntzen et al.
29433 2013, Beaulieu et al. 2016, 2018, Bevelhimer et al. 2016, Del Sontro et al. 2010, Descloux et al.
29434 2017). In response to Deemer et al. (2016), the Corps' Walla Walla District evaluated the
29435 potential for methane generation specifically from dams and reservoirs in the lower Snake River
29436 (Corps 2016a). The evaluation concluded that "for the relatively clean reservoirs of the Federal
29437 Columbia River Power System, which include the lower Snake River dams, conditions for low
29438 dissolved oxygen concentrations are not prevalent; thus methane gas is generally not an issue"
29439 (Corps 2016a).

29440 The NW Council concluded that insufficient data was available to estimate reservoir methane
29441 emissions specifically for the Columbia River hydrosystem (NW Council 2017c). The NW Council
29442 also found that methane emissions at high levels are not likely due to the lower organic and
29443 nutrient loads to the system, and higher dissolved oxygen content (NW Council 2017). Appendix
29444 G, *Air Quality and Greenhouse Gas Emissions*, of this EIS further discusses reservoir methane
29445 emissions and the relevant literature.

29446 **SOCIOECONOMIC IMPLICATIONS OF GREENHOUSE GAS EMISSIONS**

29447 GHG emissions influence a variety of socioeconomic outcomes related to climate change,
29448 including agricultural productivity, human health, flood risk, and infrastructure and fishery
29449 damages. The value of reducing levels of GHGs in the atmosphere is the avoided damages that
29450 would be generated by a unit of GHG if it were present. Economists express this value in
29451 monetary terms representing society's willingness to pay to avoid climate-related impacts
29452 associated with an additional unit of a GHG in the atmosphere. This value is defined as the
29453 "social cost" of GHGs. The more common term, "social cost of carbon" (SCC), generally pertains
29454 to CO₂ emissions.

29455 Social costs are generally presented under multiple different scenarios according to different
29456 future carbon distribution scenarios (e.g., average, higher-than-expected) and discount rate
29457 assumptions. The distributions in the value of the social costs reflect the uncertainty associated
29458 with the calculation of marginal climate-related impacts. The social cost values grow over time,
29459 reflecting growth in incremental damages as the magnitude of climate-related damages
29460 increases. Because GHGs affect climate change and associated socioeconomic impacts at a
29461 global level, social cost of GHG metrics are generally presented as global measures of
29462 socioeconomic impact, independent of the geographic source of the emissions.

29463 The academic literature and Federal agency guidance on these measures is actively evolving. A
29464 Federal interagency working group on the social cost of GHGs formerly issued guidelines that
29465 were updated over time (the most recent was in August 2016) to help agencies assess the
29466 climate change-related benefits of reducing carbon emissions and integrate these estimates
29467 into their assessments of regulatory impacts in cost-benefit analyses (Interagency Working
29468 Group on Social Cost of Greenhouse Gases, United States Government 2016). The interagency
29469 guidance provided a SCC dollar value based on the average of three integrated assessment
29470 models. The socioeconomic effects of changes in emissions are calculated by multiplying the
29471 change in emissions in a given year by that year's SCC value. The net present value of the
29472 benefits can then be calculated by multiplying each of these future benefits by an appropriate
29473 discount factor and summing across affected years.

29474 In January 2017, a National Academy of Sciences report recommended changes in the
29475 framework being used by Federal agencies for estimating the social cost of GHGs to improve
29476 transparency and better reflect uncertainty. Particular issues highlighted were: (1) the selection
29477 of appropriate discount rates for intergenerational effects of climate change; (2) best methods
29478 for reflecting uncertainty related to climate change and economic growth projections; and (3)
29479 appropriate consideration of global versus domestic societal benefits of avoided damages.

29480 In March 2017, Executive Order 13783 on Promoting Energy Independence and Economic
29481 Growth withdrew the Interagency Working Group's technical documents related to measures
29482 of the SCC generally used by Federal agencies for policy analysis. As of January 2019, no formal
29483 Federal agency guidance regarding social cost of GHG metrics exists. At the state level,
29484 however, the Washington Utilities and Transportation Commission recently directed utilities to

29485 evaluate the monetary costs associated with GHG emissions using the former interagency
29486 working group guidance (Washington Utilities and Transportation Commission 2018).

29487 The literature identifies an average social cost per ton of carbon dioxide of \$42 for the year
29488 2020 (2007 dollars, assuming a discount rate of 3 percent), though the value varies between
29489 \$12 per ton and \$123 dollars per ton depending on the carbon distribution scenario and
29490 discount rate assumption (Marten et al. 2015). There are differences in the social cost measures
29491 for different GHGs because of differences in the “global damage potential” of the GHGs. While
29492 global warming potential of GHGs account for the differences in radiative forcing of the gases as
29493 compared with CO₂, global damage potential captures the differences across gases in terms of
29494 climate-related damages.

29495 **3.8.3 Environmental Consequences**

29496 This section evaluates how the CRSO EIS alternatives may affect air quality and greenhouse gas
29497 (GHG) emissions. The section also discusses the potential for health and environmental effects
29498 of air quality changes, and the socioeconomic implications of the changes in GHG emissions.
29499 The analysis relates the findings of other resource analyses in this EIS, to the consequent effect
29500 on air pollutant and GHG emissions, including Section 3.7, *Power Generation and Transmission*,
29501 and Section 3.10, *Navigation and Transportation*.

29502 Table 3-200 provides an overview of the effect determinations.⁹ Overall, air quality and GHG
29503 emissions would most likely improve relative to 2016 conditions under the No Action
29504 Alternative.

29505 Table 3-200 identifies the effects of the MOs relative to the No Action Alternative. Cumulative
29506 effects including air quality are discussed in Chapter 6. Analysis of the preferred alternative is
29507 included in Chapter 7. The loss of emissions-free hydropower generation in MO1, MO3, and
29508 MO4 has the potential to degrade air quality and increase GHG emissions and criteria pollutant
29509 emissions by increasing fossil fuel generation. However, current trends towards
29510 decarbonization may lead to the replacement of some or all of the reductions in hydropower
29511 generation with zero-emitting power resources. If the reduction in hydropower generation is
29512 replaced by zero-emitting power resources, then MO1 would likely have negligible to minor
29513 beneficial effects on air quality and GHG emissions by reducing fossil fuel generation relative to
29514 the No Action Alternative. Under MO2, the increased hydropower generation has the potential
29515 to offset fossil fuel generation, reducing overall electricity-sector emissions and resulting in
29516 minor beneficial effects to air pollutant emissions, air quality, and GHG emissions. Under MO3
29517 and MO4, however, the reduction in hydropower would most likely increase reliance of the
29518 energy sector on fossil fuels to meet demand regardless of the types of replacement resources
29519 developed because, even with the zero-carbon replacement power resources, fossil fuel

⁹ This analysis does not present results according to the CRSO regions for two reasons: first, the specific locations of replacement power resources that lead to the emissions changes are uncertain; second, as the climate-related effects of GHG emissions are inherently a global, cumulative effect, the geographic location of the emission sources is immaterial.

29520 generation would still be needed to provide power during peak loads (e.g., winter cold snaps
29521 and summer heat waves). Further, MO3 would increase vehicle traffic due to limitations on
29522 navigation in the lower Snake River. Potential future coal plant retirements are a key source of
29523 uncertainty in this analysis with implications on the ability to replace the loss of hydropower
29524 generation with zero-emitting resources. Section 3.8.3.3, *Multiple Objective Alternative 1*,
29525 therefore includes an analysis that considers how potential future coal plant retirements may
29526 affect this analysis.

29527 **Table 3-200. Summary of Air Quality and Greenhouse Gas Emissions Effects by Alternative**

Alternative	Air Quality Effects	GHG Emissions Effects
No Action Alternative	Air quality would most likely be improved relative to 2016 conditions. The 2022 power generation analysis includes less generation and associated pollution from fossil fuels, and current trends toward decarbonization, including potential coal plant retirements, would likely result in improved air quality.	GHG emissions would most likely reduce relative to 2016 levels. The 2022 power generation analysis includes less generation and associated GHG emissions from fossil fuels largely driven by current trends toward decarbonization, including potential coal plant retirements. From 2022 through 2041, emissions from power generation hold relatively steady; however, potential future changes in the power sector, including additional coal plant retirements, contribute uncertainty to the level of fossil fuel generation under the No Action Alternative.
MO1	<p>Short-term, minor adverse effects in Region D: Construction-related air pollutant emissions due to multiple structural projects at McNary Dam.</p> <p>Negligible effects in all other regions: Energy sector-related emissions most likely negligible or lead to slightly beneficial effects relative to the No Action Alternative (assuming hydropower replaced by zero-carbon resources). All other sources of emissions negligible.</p>	<p>Negligible to potentially minor adverse or minor beneficial effects across regions: The reduction in hydropower generation could potentially increase GHG emissions. However, if the region is able to replace the reduction in hydropower with zero-carbon resources, GHG emissions from power generation may be slightly reduced. Potential increase in GHG emissions from construction-related activities; likely short term and very limited compared with the reductions in emissions from power generation.</p>
MO2	<p>Minor beneficial effects: Increased hydropower would reduce regional reliance on fossil fuels relative to No Action Alternative. No change in other emissions sources. Benefit occurs broadly across regions with the exception of localized adverse effects.</p> <p>Short-term, minor adverse effects in Region C: Potential for localized fugitive dust emissions at Dworshak Dam due to reduced reservoir water levels.</p>	<p>Minor beneficial effects: Increased power generation from hydropower (no associated emissions) would reduce generation from fossil fuels, thus decreasing GHG emissions. No change in other emissions sources.</p>

Alternative	Air Quality Effects	GHG Emissions Effects
MO3	<p>Long-term, moderate, adverse effects in Regions C and D: Reductions in hydropower lead to increased fossil fuel generation and associated emissions, most likely from natural gas plants in Region D, and coal in Wyoming and Montana. Potential for increased emissions associated with increased truck transport along the lower Snake River to replace barges.</p> <p>Short-term, moderate adverse effects in Region C: Construction activities, including dam breaching, would generate emissions during the period of construction, localized to the project sites. Additionally, exposed riverbed along the Snake River would increase the potential for fugitive dust emissions in Region C.</p>	<p>Long-term, moderate, adverse effects on GHG emissions: Reductions in hydropower lead to increased GHG emissions from fossil fuel generation, even under a zero-carbon replacement portfolio, most likely from natural gas in Region D, and coal in Wyoming and Montana. Potential for increased emissions associated with increased truck transport along the lower Snake River to replace barges.</p> <p>Short-term, minor adverse effects on GHG emissions: Construction activities, including dam breaching, would generate emissions during the period of construction, localized to the project sites. These are likely to be minor relative to the energy sector emissions effects.</p>
MO4	<p>Long-term, moderate adverse effects in Montana and Wyoming: Reductions in hydropower generation increase coal generation and associated air pollutant emissions in Wyoming and Montana.</p> <p>Short-term, minor adverse effects in Regions A, C, and D: Construction activities related to structural measures and construction of replacement power resources would generate air pollutant emissions, localized to the project sites. Additionally, reduced reservoir elevation levels at Hungry Horse Dam in Region A may increase fugitive windblown dust and associated PM emissions.</p>	<p>Long-term, moderate adverse effects from emissions in Wyoming and Montana: Reductions in hydropower lead to increased GHG emissions from fossil fuel generation, primarily from coal in Montana and Wyoming, even under the zero-carbon replacement portfolio.</p> <p>Short-term, minor adverse effects from emissions in Region C: Construction activities would generate emissions during the period of construction, localized to the project sites. This effect is likely to be minor relative to the energy sector emissions effects.</p>

29528 Note: These effects reflect the base case power analysis, which accounts for the retirements of Colstrip 1 and 2
 29529 not all recently announced coal power plant closures. See the Methodology below and the power analysis (Section
 29530 3.7) for further details.

29531 **3.8.3.1 Methodology**

29532 This analysis undertakes a qualitative assessment of the expected effects of the MOs on air
 29533 quality. Similarly, analysis of GHG emissions effects from construction activities and other
 29534 sources (e.g., reservoir methane and exposed sediment) is qualitative. Where potential air
 29535 quality and greenhouse gas emissions effects are tied to a specific region (Regions A-D), it is
 29536 specifically discussed within the analysis.

29537 However, as electricity-sector GHG emissions are a focus of evolving regulatory and policy
 29538 initiatives in the Pacific Northwest, this analysis quantifies the effects of the MOs on GHG
 29539 emissions from power generation. Additionally, as the transportation sector is a key source of
 29540 regional GHG emissions, this analysis conducts a quantitative analysis of the expected effects of
 29541 the alternatives on navigation- and transportation-related GHG emissions.

29542 Effects of the MOs are characterized as beneficial or adverse, as defined by the magnitude of
29543 effect classifications. The analysis considers context, intensity, and duration to determine
29544 whether effects are negligible, minor, moderate, or major. The intensity of effects for air quality
29545 considers whether criteria air pollutant changes are likely to exceed *de minimis* emissions as
29546 defined by the EPA.¹⁰ For other non-criteria air pollutants, the analysis references the relative
29547 change in the emitting activities as compared with the No Action Alternative (e.g., the changes
29548 in power generation from coal and natural gas power plants).

29549 **ANALYTICAL APPROACH FOR AIR QUALITY EFFECTS**

29550 **Power Generation**

29551 Sulfur dioxide (SO₂), carbon monoxide (CO), nitrous oxides (NO_x), particulate matter (PM),
29552 HAPs, and VOCs are air pollutants that are directly emitted from fossil fuel combustion. This
29553 analysis provides a qualitative assessment of the expected direction (beneficial or adverse) and
29554 magnitude of changes in air quality resulting from electricity generation in the Pacific
29555 Northwest based on several factors:

- 29556 • Locations of emissions (context): Determining the implications of the emissions changes on
29557 ambient air quality requires referencing the geographic locations of the emissions sources,
29558 and comparison with the existing ambient air quality and sensitive areas in those regions
29559 under the No Action Alternative (e.g., presence of nonattainment or maintenance areas for
29560 criteria pollutants, or presence of protected scenic areas).
- 29561 • Changes in the fuel mix (intensity): Evaluating the magnitude of the emissions changes
29562 requires understanding how the MOs differ from the No Action Alternative with respect to
29563 the relative level of generation from fossil fuel-based sources over time.
- 29564 • Timeframe of emissions effects (duration): Generally, the changes in the fuel mix, and
29565 associated emissions effects under the alternatives, would be long-term effects expected to
29566 persist into the foreseeable future.

29567 For alternatives that may adversely affect air quality, the analysis considers the potential for
29568 effects on human health and ecological resources. This assessment references the available
29569 literature on health and ecological effects of air pollution, as summarized in Appendix G.

¹⁰ As described in Section 3.8.2.1, EPA defines *de minimis* levels of criteria air pollutant emissions in non-attainment and maintenance areas as the minimum threshold for which a “conformity determination” must be performed (40 CFR 93. § 153). A conformity determination is not required for NEPA analysis of multiple MOs (see <https://www.epa.gov/general-conformity/general-conformity-training-module-13-background>). However, this analysis references the *de minimis* standards as an indicator of the potential intensity of the criteria air pollutant emissions effects. A conformity determination of the Preferred Alternative (discussed in Chapter 7) may be required prior to developing the Record of Decision.

29570 **Navigation and Transportation**

29571 Emissions related to barge, truck, and rail transport of goods include criteria pollutants, as well
29572 as HAPs and VOCs. The navigation and transportation emissions analysis references Section
29573 3.10, which describes the effects of the alternatives on modes (barge, rail, truck) of freight
29574 transport, focusing on the lower Snake and lower Columbia Rivers. The analysis considers
29575 where changes in barge, road, and rail transport would occur (context), the level of change
29576 relative to the No Action Alternative (intensity), and the timeframe over which the changes are
29577 expected (duration) to qualitatively evaluate the potential emissions effects of modal shifts in
29578 freight transportation.

29579 **Construction Activities**

29580 The use of construction equipment and vehicles to implement structural measures, such as
29581 dam breaching or fish passage improvements, results in air pollutant emissions. In accordance
29582 with EPA guidance, qualitative analysis of the potential effects on air pollutant emissions and
29583 ambient air quality considers the duration of equipment use, amount of equipment (context),
29584 and area of construction activities (intensity) (EPA 1995). Construction work typically results in
29585 localized air pollutant emissions, such as PM. Therefore, the analysis focuses on qualitatively
29586 assessing and describing potential air pollutant changes and air quality effects in and around
29587 construction sites. Additionally, construction-related emissions are short term, occurring during
29588 the construction and maintenance activities.

29589 **Other Air Pollutant Emissions Sources**

29590 This analysis qualitatively evaluates the potential for windblown fugitive dust from exposed
29591 sediment, based on expected reservoir elevation changes at the CRS projects, including the
29592 timing of these changes (context and duration). Specifically, the H&H analysis (Section 3.2)
29593 quantifies how the water levels would change at each CRS project, and this analysis assesses
29594 the potential for additional sediment to be exposed and suspended by wind (intensity).
29595 Additionally, the analysis considers the potential for fugitive dust from exposed lakebeds under
29596 MO3. High-wind dust events, as defined by recent EPA exceptional events guidance, involve
29597 sustained wind speeds of 25 miles per hour (mph). Based on the EPA AP-42 emissions factors,
29598 fugitive windblown dust from wind erosion of unpaved roads, agricultural activities, and heavy
29599 construction operations can occur at wind speeds above 11 mph, with larger particles settling
29600 very close to the source. Using these thresholds, this analysis examines meteorological data at
29601 several affected regional locations to assess potential fugitive dust effects under each
29602 alternative.

29603 **ANALYTICAL APPROACH FOR GREENHOUSE GAS EMISSIONS EFFECTS**

29604 **Power Generation**

29605 As described in Section 3.7, *Power Generation and Transmission*, hydropower, which does not
29606 generate GHG emissions, currently provides over half of the electricity generation in the Pacific

29607 Northwest. The MOs would affect the amount of hydropower produced by the CRS projects
29608 due to the operational and structural measures and, under MO3, dam breaching. This, in turn,
29609 would affect the fuel mix (i.e., relative contribution of generation from fossil fuels, hydropower,
29610 and other renewables) and, therefore, regional electricity-sector GHG emissions. As the power
29611 system in the Pacific Northwest is part of a broader electricity market across much of the
29612 western United States, the analysis additionally considers how changes in generation in the
29613 Pacific Northwest may result in shifting generation—and associated GHG emissions—across the
29614 Western Interconnection area (as described in Section 3.7).

29615 The assessment of the context and intensity of the GHG emissions effects is based on model
29616 outputs. The emissions estimates from electricity generation for the year 2022 are an output of
29617 the AURORA power markets model employed in the power analysis (Section 3.7). The model
29618 incorporates power plant specific emissions factors from the EPA Clean Markets data to
29619 estimate carbon dioxide (CO₂) emissions associated with the modeled power generation mix.
29620 AURORA calculates emissions based on the site of power production instead of location of
29621 consumption. For example, power generated in Washington that is consumed in California is
29622 attributed to electricity-sector emissions in Washington, not California. While AURORA only
29623 reports CO₂ emissions, not other GHGs, CO₂ is the primary source of GHG emissions from power
29624 generation, accounting for over 80 percent of energy-related emissions (EIA 2018). Thus, this
29625 analysis focuses specifically on CO₂, noting that this approach may err on the side of
29626 understating total GHG emissions changes associated with the MOs. Assessing the intensity of
29627 the GHG emissions effects of the MOs, considers that the quantified changes in carbon
29628 emissions are likely understated.

29629 The emissions outputs from AURORA for MO1, MO3, and MO4 consider two separate
29630 assumptions for how alternative sources of power generation (i.e., resource replacement)
29631 offset the expected reductions in hydropower generation from the CRS projects, to meet
29632 demand for electricity. The resource replacement analysis, described in more detail in Section
29633 3.7, considers two alternative assumptions to illustrate the range of potential outcomes. One
29634 relies on “conventional least-cost” resource replacement, which, for each of the alternatives in
29635 this analysis, is natural gas. The second, “zero-carbon,” assumes a combination of renewables
29636 and demand-response measures are used to maintain the reliability of the electricity system.¹¹
29637 Recent and emerging policy to reduce electricity-sector GHG emissions in the Pacific Northwest,
29638 indicates that the zero-carbon resource replacement portfolio may better reflect future trends.

29639 Of note, even under the zero-carbon resource replacement portfolio, natural gas and coal
29640 generation from existing plants may increase relative to the No Action Alternative. This may
29641 occur, for example, during peak demand periods, because solar and wind generation are not

¹¹ As described in Section 3.7.2, demand response is a set of resources or tools that allows electricity providers and consumers to better manage when they consume electricity. The power and transmission effects analysis in Section 3.8 defines these two alternative replacement resource portfolios. While some level of emissions are generated for development of operations and maintenance for resources such as solar and wind, the “zero-carbon” replacement portfolio name is intended to communicate that emissions are not generated through the process of producing energy at these facilities.

29642 dispatchable, whereas hydropower and fossil fuel generation can be readily ramped up to meet
29643 spikes in demand.

29644 As MO2 results in improved reliability of the electricity system as compared with the No Action
29645 Alternative, replacement resources are not necessary. For MO2, the AURORA model emissions
29646 results accordingly reflect the potential for the increased hydropower generation to offset the
29647 need for fossil fuel generation, reducing overall electricity-sector emissions.

29648 As described in Section 3.7, the power analysis forecasts power rates over a 20-year timeframe
29649 (2022 to 2041). The emissions analysis relies on AURORA outputs identifying the effects of the
29650 alternatives on the fuel mix in year 1 (2022) under each alternative, and then accounts for
29651 expected changes in generation by fuel type, described over time by the Northwest Power and
29652 Conservation Council Midterm Assessment and Seventh Power Plan (NW Council 2016b).¹²

29653 For each alternative, this analysis reports average emissions from power generation in year
29654 2022, as reported by the AURORA model in total million metric tons of carbon dioxide (MMT
29655 CO₂)—including total emissions and the change relative to the No Action Alternative—for both
29656 the Pacific Northwest and across the broader Western Interconnection electricity market.¹³ The
29657 analysis also presents estimated emissions changes (MMT CO₂) over the 20-year period of
29658 analysis for power effects (2022 to 2041).

29659 Future coal plant retirements are a source of uncertainty for this analysis. The “base-case” (i.e.,
29660 the emissions effects analysis described throughout this section) assumes continued emissions
29661 from coal plants that are expected to be operating in 2022. While coal generation declines
29662 slightly over time (at an average annual rate of 0.65 percent) according to the NW Council
29663 forecast, the 20-year analysis does not incorporate now planned and potential future additional
29664 coal plant retirements that were not known at the time the NW Council forecast was
29665 developed.¹⁴

29666 Given that state and local decarbonization policies are changing the generation portfolio in the
29667 region and across the Western Interconnection area into the 2020s and beyond, this base case,
29668 which was established for power effects modeling in 2017, no longer reflects the current
29669 understanding of the power sector over time. Accordingly, additional analysis is included to
29670 understand the implications that additional coal retirements would have on power generation
29671 and associated GHG emissions. Specifically, the analysis considers additional scenarios

¹² The NW Council’s Seventh Power Plan includes a forecast of generation by resource type (gas, coal, hydropower, etc.) through 2035. This analysis extends the forecast to 2041, assuming no change from 2035. According to the forecast, the average annual reduction in coal generation from 2022 through 2035 is 0.65 percent, and the average annual increase in natural gas generation is 0.87 percent (NW Council 2016b).

¹³ This analysis does not present results according to the CRSO regions for two reasons: first, the specific locations of replacement power resources that lead to the emissions changes are uncertain; second, as the climate-related effects of GHG emissions are inherently a global, cumulative effect, the geographic location of the emission sources is immaterial.

¹⁴ This base case reflects the planned closures of Colstrip units 1 and 2, Boardman, North Valmy unit 1 as well as Centralia unit 1. However, it does not account for more recent announcements or adjustments to move scheduled retirements earlier as discussed in the power and transmission analysis in Section 3.7.

29672 reflecting “limited coal retirement” (representing an additional 2,505 MW of coal compared
29673 with the No Action Alternative) and “no coal” (all coal is retired). This analysis is included in the
29674 power and transmission effects analysis (Section 3.7.3) and additionally incorporated in this air
29675 quality and GHG emissions analysis, as described under the No Action Alternative analysis in
29676 Section 3.8.3.2.

29677 **Navigation and Transportation**

29678 Section 3.10 describes potential changes in navigation and transportation associated with the
29679 alternatives. The analysis considers where changes in barge, road, and rail transport would
29680 occur (context), the level of change relative to the No Action Alternative (intensity) and the
29681 timeframe over which the changes are expected (duration) to evaluate the potential emissions
29682 effects of modal shifts in freight transportation. For MOs that affect changes in ton-miles of
29683 freight transport by trucks, rails, and/or barges, this analysis applies average emissions factors
29684 (described in Section 3.8.2) to quantify the GHG emissions effects.

29685 **Construction Activities**

29686 Like the air pollutant emissions, analysis of construction-related emissions is based on
29687 qualitative assessment of the extent and duration of equipment use under each alternative.
29688 GHG emissions from construction-related activity are very limited as compared with the
29689 electricity-sector emissions.

29690 **Other Greenhouse Gas Emissions Sources**

29691 The analysis considers other potential sources of GHG emissions, including methane from
29692 reservoirs as well as the carbon sequestration potential of the landscape (e.g., due to changes
29693 in the land area that is submerged under the reservoirs). As described in Section 3.8.2.2, a
29694 recent study by the Corps’ Walla Walla District, concluded that hydropower projects in the
29695 lower Snake River, as well as the Columbia River System as a whole, generally do not release
29696 methane gas due to the high oxygen and circulation levels and relatively low organic matter in
29697 the system (Corps 2016a). This analysis therefore finds that potential effects of the alternatives
29698 on reservoir methane emissions are negligible for all alternatives; a discussion of this
29699 assessment is included in Appendix G.

29700 **Meeting Emissions Reductions Targets**

29701 Section 3.8.2.2 and Appendix G describe state and local GHG emissions reductions targets,
29702 including those related specifically to the energy sector as well as more broadly across the
29703 economy. For each alternative, this analysis relates how the GHG emissions changes under each
29704 alternative would affect the states and municipalities’ efforts to meet these targets.

29705 **Social Cost of Carbon**

29706 GHG emissions influence a variety of socioeconomic outcomes related to climate change,
29707 including agricultural productivity, human health, flood risk, and infrastructure and fishery

29708 damages. This analysis monetizes these socioeconomic implications in terms of the best
29709 available information on SCC values. SCC values vary by year reflecting incremental growth in
29710 climate-related damages over time.

29711 This analysis applies year-specific social cost of carbon dioxide (SC-CO₂) values based on the
29712 August 2016 Technical Support Document developed by the Interagency Working Group on the
29713 Social Cost of Greenhouse Gases (IWG) to calculate the monetized value of incremental
29714 changes in CO₂ emissions over time (2022 to 2041) (IWG 2016). Although the IWG developed
29715 the SC-CO₂ estimates for use in the context of regulatory impact analysis and not NEPA analysis,
29716 and this Technical Support Document (IWG 2016) was withdrawn by Executive Order, it is
29717 useful to consider these values in context of the CRSO EIS because the SC-CO₂ values are
29718 frequently referenced in the context of Pacific Northwest emissions reductions targets and, in
29719 particular, currently used by the Washington Utilities and Transportation Commission to
29720 evaluate changes in GHG emissions.

29721 Appendix G provides the full SCC analysis, as summarized for each of the alternatives in this
29722 section. The results of the SCC analysis are the present value and annualized value of changes in
29723 GHG emissions in the Pacific Northwest for each action alternative as compared with the No
29724 Action Alternative. While the emissions sources described in this analysis are located in the
29725 Pacific Northwest, the SCC values reflect global benefits of avoided climate-related damages
29726 due to the reduced CO₂ emissions. According to best practices for acknowledging the
29727 considerable uncertainty associated with these estimates, this analysis additionally presents
29728 four alternative scenarios for the SC-CO₂ based on alternative discount rate assumptions, and
29729 expected temperature effects of atmospheric carbon.

29730 **3.8.3.2 No Action Alternative**

29731 Under the No Action Alternative, operations of the CRS projects would continue based on
29732 operation rules as of September 2016. The operations from 2016 onward include management
29733 of the 14 CRS projects consistent with previous biological opinions, planned maintenance in
29734 future years (e.g., including Grand Coulee Dam overhaul plus forthcoming upgrades to McNary
29735 and Ice Harbor Dam turbines), and regional load and power resource forecasts.

29736 As previously described, the effects of the alternatives on power generation in the Pacific
29737 Northwest is the primary driver of the air pollutant and GHG emissions changes in this analysis.
29738 The base-case scenario for this analysis (consistent with the base-case power generation
29739 analysis described in Section 3.7.3) finds that emissions from power generation will reflect
29740 continued coal and natural gas-based generation. Emissions are expected to be relatively
29741 constant over time under the No Action Alternative, with slight reductions due to a slight
29742 decrease in reliance on coal, but slight increase in reliance on natural gas.

29743 As previously noted, a key uncertainty of this analysis is the effect of recent legislation focused
29744 on limiting GHG emissions from electricity consumption in Washington. The 2019 Clean Energy
29745 Transformation Act (SB 5116) prescribes that no coal costs be included in utility's retail rates
29746 (except for decommissioning and remediation) by 2025. The base penalty is \$100 per MWh,

29747 and varies depending on resource type, for failure to comply. Starting in 2030, the legislation
29748 requires that 80 percent of energy sold by utilities be from carbon-free sources. It is the policy
29749 of the state that by 2045, 100 percent of energy sold by utilities should be carbon free. In
29750 addition, the Oregon Clean Energy and Coal Transition Act (2016) mandates the elimination of
29751 the cost of coal resources in retail rates of investor-owned utilities by 2030.

29752 The legislation in Washington and Oregon, among other regional GHG emissions reductions
29753 initiatives, reduces the likelihood of new fossil fuel plant construction in Washington and
29754 Oregon, and increases uncertainty regarding how the electricity sector will evolve over the
29755 coming decades under the No Action Alternative, as well as the MOs.

29756 Under the No Action Alternative, effects to air quality are anticipated to be similar in the
29757 Canadian portions as those described in the United States. However, the effects would reduce
29758 as the geographic distance from the CRS projects increase.

29759 **AIR POLLUTANTS AND AIR QUALITY UNDER THE NO ACTION ALTERNATIVE**

29760 As described in Section 3.8.2, the Pacific Northwest generally experiences good air quality.
29761 Recent years have seen reductions in fossil fuel-based electricity generation that emits
29762 pollutants and total air pollutant emissions from on-road vehicles have decreased over the last
29763 10 years (EPA 2018c). However, wildfires are a key source of air pollutant emissions
29764 (particularly PM) in the region.

29765 **Air Pollutant Emissions from Power Generation under the No Action Alternative**

29766 Air pollutants from power generation would be reduced from current levels under the No
29767 Action Alternative. For 2022, the expected fuel mix includes a reduction in fossil fuel-based
29768 generation, specifically coal. Coal is the largest contributor of air pollutants from the energy
29769 sector and existing forecasts expect a reduction in coal generation by 2032 under the No Action
29770 Alternative (EPA 2018c; NW Council 2019). If additional coal plant retirements occur in the
29771 future, this would further improve air quality over time under the No Action Alternative.

29772 Given the decrease in coal generation, air pollutant emissions under the No Action Alternative,
29773 especially SO₂, would decrease. As coal generation is reduced, generation increases from natural
29774 gas sources (which emit air pollutants at a much lower rate than coal power) and wind and solar,
29775 which do not generate air pollutant emissions (NW Council 2019). The emissions rate of SO₂ for
29776 natural gas is less than 1 percent of the SO₂ emissions from coal per MWh (Oak Ridge National
29777 Laboratory 2017). Ozone (O₃) and its precursor emissions (NO_x, CO, and VOCs), would also
29778 decrease as coal-fired power plants emit roughly five times more NO_x and CO than natural gas.

29779 The reduction in SO₂ and ozone-precursor emissions may have beneficial health and ecological
29780 effects. SO₂ exposure can lead to adverse respiratory effects such as bronchoconstriction and
29781 decreased lung function. O₃ irritates the respiratory system, reduces lung function, and can
29782 damage cells lining the lungs. Deposition of SO₂ on ecosystems results in acidification, excess

29783 nutrient enrichment, increased mercury methylation, and ultimate mercury contamination.
29784 O₃ is also harmful to plants, causing cellular damage and plant death.

29785 Due to the recent legislation focused on reducing carbon from the electricity sectors over the
29786 longer term in Washington and Oregon, the adoption of wind, solar, and other replacement
29787 resources that do not emit air pollutants may increase and, therefore, electricity-related air
29788 pollutant emissions would continue to decrease. The health and ecological benefits of the
29789 reduced air pollutant emissions would be concentrated in the areas where the coal power plants
29790 are currently located. These areas include portions of Region D near the Boardman coal power
29791 plant in Oregon, as well as near Centralia in Lewis County, Washington, northwest of Region D.

29792 **Air Pollutant Emissions from Navigation and Transportation Activities under the No Action**
29793 **Alternative**

29794 As described in Section 3.10, the navigation and transportation activity most relevant to this
29795 analysis is freight transport. Regionally, the air pollutant emissions from commercial marine
29796 transportation (which includes shipping along the lower Snake and lower Columbia Rivers) are a
29797 small fraction of emissions for most air pollutants from navigation and transportation, ranging
29798 from 4.7 percent of NO_x to as low as 0.1 percent of CO (EPA 2017). However, marine vessels do
29799 emit large quantities of SO₂, and contribute over three quarters of regional transportation-
29800 related SO₂ emissions. Light-duty vehicles also emit HAPs.

29801 The navigation and transportation analysis does not identify shifts in freight transport under the
29802 No Action Alternative over time (i.e., no modal changes expected). However, there is potential
29803 for additional clean fuel standards, such as the Cleaner Trucks Initiative. The Cleaner Trucks
29804 Initiative does not have specific public targets yet but signaled the intent to update NO_x
29805 standards for trucks in early 2020 (EPA 2018c). The Washington State Clean Fuels Standard,
29806 which did not pass, would have targeted a reduction in GHG emissions of 10 percent by 2028
29807 and 20 percent by 2025 (Washington State Legislature 2019a). While this does not directly
29808 target air pollutants, reducing GHG emissions results in co-benefits of reduced air pollutant
29809 emissions. Should standards like these pass, a reduction in air pollutant emissions from
29810 navigation and transportation sector under the No Action Alternative may occur.

29811 **Air Pollutant Emissions from Construction Activities under the No Action Alternative**

29812 The No Action Alternative includes nine project-specific structural measures that have the
29813 potential to generate air pollutant emissions from use of construction equipment. Most of
29814 these projects are complete or will be completed in 2019 (e.g. John Day adult PIT antennas in
29815 2016–2017 and the Lower Granite PIT monitoring in 2019). The other structural measures in the
29816 No Action Alternative occur at Bonneville and Little Goose. Bonneville, in Region D, would have
29817 gatewell improvements at the second powerhouse. Little Goose, in Region C, would have a
29818 spillway weir gate hoist installed, as well as adult ladder improvement.

29819 The emissions from construction activities include PM from disturbing roadways and other
29820 criteria pollutant and HAPs emissions from the burning of fuel for equipment and vehicles.

29821 In addition, crushing and grinding operations associated with construction can
29822 generate PM, solid particles and liquid droplets suspended in air (EPA 2018a). Such pollutants
29823 irritate the eyes, nose, and throat, and carry toxic metals. Exposure to PM is associated with
29824 health effects, especially those with already diminished pulmonary or cardiac capacities and
29825 young children; including aggravated asthma, bronchitis, and irregular heartbeats. However,
29826 given the short-term nature and limited geographic scope of these effects around the project
29827 site, the emissions effects are most likely minor under the No Action Alternative. Moreover,
29828 construction-related BMPs may avoid or minimize the potential adverse effects of air pollutants
29829 from construction activities. Construction-related BMPs include minimizing dust becoming
29830 airborne (e.g., watering surfaces, applying dust suppressants, laying gravel); managing vehicle
29831 emissions and dust (e.g., restricting speeds, using paved roads, reducing idle times); and direct
29832 emissions management (e.g., replacing outdated equipment, installing emissions reductions
29833 technologies, using ultra-low sulphur fuel for off-road equipment) (Western Regional Air
29834 Partnership 2006; EPA 2010; Corps 2014). These guidelines provide practices for ensuring
29835 efficient fuel use and protection of the surrounding populations and habitat.

29836 **Other Air Pollutant Emissions Sources under the No Action Alternative**

29837 If reservoir levels are lowered for extended periods, fugitive dust emissions may be a concern.
29838 Fugitive dust results in localized air quality effects based on which reservoirs experience
29839 elevation changes (San Joaquin Valley 2011). Adverse health and environmental consequences
29840 can occur from intense concentrated dust events, particularly if there are any contaminated
29841 sediments suspended (EPA 2017). However, Section 3.3.3, *River Mechanics*, finds that shoreline
29842 exposure effects, and the potential for changes in the reservoir elevation at CRS projects, are
29843 negligible under the No Action Alternative. By extension, this analysis expects negligible
29844 associated air quality effects.

29845 **GREENHOUSE GAS EMISSIONS UNDER THE NO ACTION ALTERNATIVE**

29846 Power generation is the primary source of GHG emissions of relevance to this EIS. In accordance
29847 with the multiple state and local-level initiatives to reduce GHG emissions from electricity
29848 generation, changes in the fuel mix over time under the No Action Alternative are most likely to
29849 favor low-carbon resources, such as solar and wind, as well as demand -response measures.

29850 **Greenhouse Gas Emissions from Power Generation under the No Action Alternative**

29851 The AURORA model outputs identify total CO₂ emissions from power generation in the Pacific
29852 Northwest of approximately 36.7 MMT CO₂ in 2022.¹⁵ These emissions are from electricity

¹⁵ A considerable fraction of the emissions are associated with generation from two coal plants, Jim Bridger in Wyoming and half of the remaining generation from North Valmy in Nevada. Both lie outside the Pacific Northwest; however, the NW Council considers them regional resources because they supply power directly to Pacific Northwest consumers (NW Council 2016, 2019). All generation from Jim Bridger serves Pacific Northwest customers as does half of the remaining generation from North Valmy. While this consumption-based approach contrasts with AURORA production-based emissions estimates, these emissions are included to ensure generation and emissions are consistent with historical NW Council data and forecasts relied on in this analysis (NW Council

29853 generated in the region. The 90 percent confidence interval for emissions from AURORA is 29 to
29854 45 MMT CO₂.

29855 Estimates of the monthly mean CO₂ emissions from the AURORA power model range from
29856 0.81 to 2.6 MMT CO₂. Over the course of the year, December has the highest total GHG
29857 emissions while June has the lowest due to changes both in monthly hydropower generation
29858 and in average monthly demand for electricity. Given that hydropower generation increases
29859 in the spring months due to greater water supply from snowmelt runoff, fossil fuel generation
29860 can decrease during those months. The emissions trend depicts the decrease in use of coal and
29861 natural gas sources for generation in the spring months (April, May, June).

29862 Under the base case for the No Action Alternative, predicted regional emissions would be
29863 relatively steady at these levels over time, reflecting continued generation from coal and
29864 natural gas resources, constant hydropower, and new renewable power. This is based on the
29865 forecast of the generation fuel mix over time described in the Seventh Power Plan and Midterm
29866 Assessment, which describes that average annual generation from coal would decrease over
29867 time at a rate of 0.65 percent and average annual generation from natural gas would increase
29868 over time at a rate of 0.87 percent (NW Council 2016b, 2019).

29869 However, as previously described, recent and emerging policy focused on reducing energy-
29870 sector GHG emissions may influence how power is generated over time under the No Action
29871 Alternative. For example, the Washington Clean Energy Transformation Act includes increasing
29872 price penalties per MWh of fossil fuel generation in Washington. By 2045, all Washington
29873 utilities must sell carbon-free power, likely increasing renewable generation and reducing
29874 emissions over time. Additionally, the Oregon Clean Energy and Coal Transition Act (2016)
29875 requires eliminating the cost of coal resources in retail rates of investor-owned utilities by 2030.
29876 Of note, however, some level of fossil fuel generation is expected as other states within the
29877 region (e.g., Montana and Idaho¹⁶) are not currently planning emissions reductions targets at
29878 the level of Washington and Oregon.

29879 Specifically, retirements of coal-fired power plants would reduce GHG emissions because coal is
29880 the largest emitter of GHGs per MWh of all power generation types. This analysis finds that the
29881 forecast of GHG emissions under the No Action Alternative and the MOs is very sensitive to
29882 assumptions regarding the future availability of coal resources and the future fuel mix. The
29883 power analysis presents results of an analysis that considers alternative assumptions regarding
29884 the level of coal capacity available to serve regional loads and the amount of zero-carbon
29885 resources needed to maintain that ability to serve regional loads. As described in more detail in
29886 Section 3.7.3, the analysis considers two possible future
29887 conditions: (1) “limited coal” reflects closure of most, but not all, coal plants (1,741 MW of coal

2016b, 2019). Over the last 3 years of available data, the EPA estimated Jim Bridger emitted an average of 14.2 MMT CO₂, and 900,000 tons of CO₂ for the remaining half of North Valmy (assuming North Valmy Unit 1 retires by 2022 and so these emissions are associated with the remaining Unit 2). Half of the remaining emissions (474,000 tons of CO₂) are associated with generation that serves the Pacific Northwest.. (EPA 2018b; NW Council 2019).

¹⁶ Idaho Power is planning to phase out fossil fuel generation by 2045
(<https://www.idahopower.com/energy/clean-today-cleaner-tomorrow/>).

29888 remaining) and (2) “no coal” reflects complete elimination of all coal capacity (0 MW of coal
29889 remaining).

29890 Because coal combustion results in the greatest level of GHG emissions per unit of power
29891 generated, energy sector GHG emissions in the Pacific Northwest would be lower under either
29892 of the future coal conditions. The specific magnitude of emissions reductions under the “limited
29893 coal” and “no coal” conditions is uncertain and depends on the extent to which sufficient
29894 renewable resource capacity may be added to the system to replace the reduction in coal.
29895 Regional GHG emissions would be considerably lower if renewable resources that do not
29896 generate emissions replace the coal. However, if the reduction in coal capacity results in some
29897 increase in fossil fuel-based generation (e.g., natural gas), the emissions reduction benefit
29898 would be less.

29899 Coal, along with natural gas and hydropower, are considered “dispatchable” resources,
29900 meaning they can generally be used to generate power that is then delivered on demand to
29901 meet market needs. However, with the exception of hydropower, these power resources
29902 generate GHG emissions. Solar and wind resources do not generate emissions but are also
29903 generally not dispatchable without a source of storage as their ability to generate power relies
29904 on external factors (i.e., sufficient sun and wind). Thus, a reduction in dispatchable coal capacity
29905 under the No Action Alternative, and the added loss in dispatchable hydropower under MO1,
29906 MO3, and MO4, would result in the need for a large amount of additional renewable power
29907 resources to meet regional power reliability standards, as described in Section 3.7.3 and
29908 Appendix G. As described in Section 3.7, *Power Generation and Transmission*, electricity
29909 generation and consumption in the Pacific Northwest is part of a broader market that spans
29910 much of the western United States. Therefore, this analysis also considers GHG emissions
29911 across the broader Western Interconnection area. Changes in generation in the Pacific
29912 Northwest may result in shifting generation more broadly across the Western Interconnection
29913 area. Under the No Action Alternative, average annual emissions from electricity generation
29914 across the Western Interconnection area under the base case are 163 MMT CO₂.

29915 The Western Electricity Coordination Council 2028 Anchor Data Set provides the best available
29916 information on potential changes to the power system over time for the entire Western
29917 Interconnection area. As with the Pacific Northwest, emissions are likely to decrease over time
29918 due to power plant retirements and their replacement with renewable power (WECC 2019).
29919 The net effect over the next 10 years is a reduction in high emitting power, such as coal, and
29920 replacement with natural gas and non-emitting renewables, decreasing overall energy-sector
29921 GHG emissions.

29922 **Greenhouse Gas Emissions from Navigation and Transportation under the No Action** 29923 **Alternative**

29924 The primary commodity that relies on navigation by barge on the Snake River that may be
29925 affected by the MOs is wheat, which is being transported primarily to regional ports for export.
29926 Under the No Action Alternative, barge traffic remains the primary transportation method for
29927 wheat at 1.1 billion ton-miles expected in 2022 (Section 3.10). Rail and truck move 820 million

29928 and 460 million ton-miles of wheat, respectively. The emissions from all three modes of freight
29929 transportation for wheat in the region are expected to be 0.11 MMT CO₂ in 2022. Truck
29930 transportation is the main source of emissions at 68 percent. Barges account for 16 percent of
29931 the expected emissions, despite carrying five times more freight than trucks. Rail accounts for
29932 the remaining 16 percent of emissions. These emissions represent less than 1 percent of
29933 regional transportation-related CO₂ emissions.

29934 As previously mentioned, uncertainty exists regarding the future levels of emissions from the
29935 transportation sector under the No Action Alternative. In 2019, Washington tried but failed to
29936 pass a clean fuel standard. Oregon already has a clean fuels standard in place targeting a 10
29937 percent reduction by 2026 (ODEQ 2018b).

29938 **Greenhouse Gas Emissions from Construction**

29939 As previously described, structural measures for No Action Alternative that could generate
29940 GHG emissions from construction activity largely have been or will be completed in 2019.
29941 These activities would likely involve construction vehicles and equipment to remove outdated
29942 equipment or structures, and construct improvements. The duration of construction projects
29943 for these structural measures would determine how much fuel is combusted. Construction
29944 equipment tends to use diesel fuel, which generates more GHG than regular gasoline, and off-
29945 road equipment is often less efficient than on-road vehicles (EPA 2018d).

29946 Implementation of the structural measures in No Action Alternative does not involve
29947 forecasting construction equipment use over extended periods of time. BMPs for reducing
29948 emissions, as previously described, may reduce the intensity of these activities and, given the
29949 limited level future construction activity under the No Action Alternative, construction-related
29950 GHG emissions are likely negligible.

29951 **Other Greenhouse Gas Emissions Sources under the No Action Alternative**

29952 As previously described, hydropower projects in the lower Snake River and lower Columbia
29953 River generally do not release methane gas from the reservoirs due to the high oxygen and
29954 circulation levels and relatively low organic matter in the system (Corps 2016). This is not
29955 expected to change over time under the No Action Alternative.

29956 **Meeting Emissions Reductions Targets under the No Action Alternative**

29957 In Washington, the GHG emissions reduction target for all sectors is 25 percent below 1990
29958 levels by 2035, and for Oregon the target for 2050 is 75 percent below 1990 levels. Both states
29959 also have 2020 target goals (reaching 1990 levels for Washington and 10 percent below 1990
29960 levels for Oregon). Section 3.8.2 provides additional details on state level targets and Appendix
29961 G lists regional county or local level targets.

29962 The trends under the No Action Alternative for reduced electricity-sector carbon emissions are
29963 beneficial for meeting overall GHG emissions reductions targets. However, further reductions in

29964 emissions would be required to meet the state targets and the Washington Clean Energy
29965 Transformation Act than the reductions forecast under the No Action Alternative base case.

29966 **Social Cost of Carbon under the No Action Alternative**

29967 The SCC analysis quantifies the value of the change in emissions relative to No Action
29968 Alternative. For comparison with the quantified changes, however, this analysis finds that the
29969 total electricity-sector emissions in the Pacific Northwest over a 20-year time period (2022 to
29970 2041), result in a present value cost of \$31 billion (assuming a 3 percent discount rate).

29971 **SUMMARY OF EFFECTS**

29972 Air pollutants from power generation would be reduced from current levels under the No
29973 Action Alternative, assuming a continued reduction in coal generation. Additional clean fuel
29974 standards could lead to a decrease in emissions associated with transportation and navigation
29975 activities. The No Action Alternative includes nine project-specific structural measures that have
29976 the potential to generate air pollutant emissions from use of construction equipment. Under
29977 the base case for the No Action Alternative, predicted regional emissions would be relatively
29978 steady at these levels or reduced relative to 2016 levels over time, reflecting continued
29979 generation from coal and natural gas resources, constant hydropower, and new renewable
29980 power.

29981 **3.8.3.3 Multiple Objective Alternative 1**

29982 MO1 includes various structural and operational measures that have the potential to affect
29983 regional air pollutant and GHG emissions. Operational measures in MO1, including various
29984 water management changes such as modifying draft rates and manipulating reservoir levels,
29985 have the collective effect of reducing the overall level of hydropower generation in the region.
29986 This would result in the need for power replacement resources that affect energy-sector air
29987 pollutant and GHG emissions. Additionally, structural measures such as modifications for
29988 spillways and other upgrades at the CRS projects would require construction that generates
29989 short-term emissions during the construction period.

29990 Under MO1, effects to air quality are anticipated to be similar in the Canadian portions as those
29991 described for the United States. However, the effects would reduce as the geographic distance
29992 from the CRS projects increase.

29993 **AIR POLLUTANTS AND AIR QUALITY UNDER MULTIPLE OBJECTIVE 1**

29994 **Air Pollutant Emissions from Power Generation under Multiple Objective Alternative 1**

29995 Under MO1, average generation from hydropower in the Pacific Northwest in 2022 is
29996 approximately 1 percent less than under the No Action Alternative (based on AURORA model
29997 outputs). The consequences of this for air pollutant emissions depend on resource replacement
29998 assumptions. Under the conventional least-cost resource replacement portfolio, increased
29999 generation from natural gas would increase air pollutant emissions, in particular NO_x and to a

30000 lesser degree SO₂ and PM, near the sites of the generation resources. Given that natural gas
30001 generation increases by 2.4 percent in the Pacific Northwest under MO1, criteria pollutant
30002 emissions would likely increase slightly as compared to No Action Alternative. The changes in air
30003 pollutant emissions would occur primarily in Region D near McNary Dam as the increased
30004 natural gas generation would likely be focused in that area (Section 3.7, *Power Generation and*
30005 *Transmission*). Any additional fossil fuel generation would be subject to and controlled by the
30006 applicable emissions permitting and regulation as described in Section 3.8.1. There are no
30007 nonattainment areas for O₃ or O₃ precursors in this area, and the increase in natural gas is
30008 unlikely to risk adherence to NAAQS or reach EPA *de minimis* thresholds.

30009 However, under the zero-carbon resource replacement portfolio, focused primarily on
30010 increasing generation from solar projects, air pollutant emissions experience a slight decrease
30011 relative to No Action Alternative. This is due to a reduction in natural gas generation of
30012 3.6 percent relative to No Action Alternative because the added solar power capacity
30013 additionally reduces some natural gas generation. As previously described, recent and emerging
30014 policy focused on reducing energy sector GHG emissions indicates that the zero-carbon
30015 resource replacement portfolio may better reflect future trends. Thus, the effects of MO1 on
30016 air pollutant emissions from power generation may be beneficial due to the slight reduction in
30017 fossil fuel combustion.

30018 **Air Pollutant Emissions from Navigation and Transportation under Multiple Objective**
30019 **Alternative 1**

30020 MO1 would not affect the level of barge transportation or river navigation in the region; thus,
30021 this analysis does not expect effects on navigation and transportation-related air pollutant
30022 emissions. As described in Section 3.10.3, changes to the cost of shipping on the Columbia and
30023 Snake Rivers under MO1 would be less than 1 percent, and the changes to river flows would be
30024 minimal.

30025 **Air Pollutant Emissions from Construction Activities under Multiple Objective Alternative 1**

30026 Structural measures under MO1 include upgrading weirs, lamprey modifications, and improving
30027 turbines. The structural measures are focused in Region C and D at Bonneville, McNary, and
30028 John Day Dams, and the lower Snake River projects. Construction activities involving additional
30029 vehicle and equipment use would result in additional pollutant emissions. These construction
30030 activities include new passage routes for fish at McNary and Ice Harbor, as well as modifications
30031 and additions to other fish bypass structures. The magnitude of these construction activities
30032 varies but all would require machinery and equipment as well as vehicle travel to the site,
30033 which increase air pollutants, especially PM, relative to No Action Alternative.

30034 In addition, construction of replacement power resources (natural gas or solar power plants)
30035 under MO1, would result in vehicle and equipment-related emissions. Solar power does not
30036 produce air pollutants when generating, but has the potential to produce pollutants, specifically
30037 PM, from construction activities and construction vehicles travelling on unpaved roads
30038 (EPA 2017). Both resource replacement portfolios would have short-term and localized adverse

30039 effects due to increased air pollutants relative to No Action Alternative, though the exact
30040 location of these potential power generation resources and hence pollutants is uncertain.

30041 Overall under MO1, implementation of the structural measures and construction of
30042 replacement resources would increase air pollutant emissions. These emissions would be
30043 localized to the project site and short term; occurring during the period of construction.¹⁷
30044 Of note, certain construction activities, specifically at McNary and Ice Harbor Dams (Regions C
30045 and D) would occur in proximity to the Wallula maintenance area for PM₁₀. Adoption of BMPs
30046 (as previously described) to reduce PM emissions from construction activities may mitigate
30047 adverse effects.

30048 **Other Air Pollutant Emission Sources under Multiple Objective Alternative 1**

30049 Relative to the No Action Alternative, reservoir levels under MO1 would fluctuate more than
30050 2 feet at four CRS projects (Dworshak, Grand Coulee, Libby, and Hungry Horse Dams), resulting
30051 in exposed sediment during drawdown operations. Exposed sediment could become suspended
30052 PM under certain conditions, such as high temperatures, a lack of precipitation, and wind
30053 erosion. The River Mechanics analysis (Section 3.3.3.5) considers the change in the amount of
30054 time that elevations remain at low levels under MO1, and determined this impact would be
30055 negligible; therefore, this analysis likewise finds a negligible effect on air quality. In addition, the
30056 wind speeds at nearby regional monitoring sites are relatively low compared to the speed
30057 threshold for windblown dust, making the potential for fugitive dust and high-wind dust events
30058 relatively low. Appendix G provides more information on wind speeds and frequencies.

30059 **GREENHOUSE GAS EMISSIONS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 1**

30060 Generally, the direction of effect on GHG emissions (beneficial or adverse) from the various
30061 sources mirrors the direction of the effect on air pollutant emissions. Under the conventional
30062 least-cost resource replacement portfolio, emissions would increase slightly, whereas under the
30063 zero-carbon resource replacement portfolio, emissions would decrease slightly relative to the
30064 No Action Alternative. Short-term increases in GHG emissions from construction-related
30065 activities would most likely be negligible.

30066 **Greenhouse Gas Emissions from Power Generation under Multiple Objective Alternative 1**

30067 MO1 would result in a reduction in hydropower generation. As described in Table 3-201, this
30068 analysis estimates CO₂ emissions from power generation under MO1 according to both the
30069 conventional least-cost and zero-carbon resource replacement portfolios, as well as for the
30070 Pacific Northwest and the broader Western Interconnection area. For the conventional least-
30071 cost power portfolio, emissions would be 37.0 MMT CO₂ in 2022 across the Pacific Northwest,
30072 a less than 1 percent increase from the No Action Alternative. However, given that policy and
30073 legislative decisions in Oregon and Washington are targeting large reductions in GHG emissions,

¹⁷ To the extent this analysis identifies potential resource replacement needs, additional site-specific planning, analysis, and compliance with environmental laws, including NEPA, would be required.

30074 a 1 percent increase in GHG emissions under the conventional least-cost power portfolio makes
30075 this goal more difficult to achieve. These changes are due to an increase in natural gas
30076 generation. Under the zero-carbon portfolio, emissions would be 36.2 MMT CO₂ in 2022, a
30077 roughly 1 percent reduction in overall emissions as compared with the No Action Alternative.
30078 These changes are due to reductions in natural gas generation and increased solar generation.

30079 As previously described, recent and emerging policy focused on reducing energy-sector GHG
30080 emissions indicates that the zero-carbon resource replacement portfolio may better reflect
30081 future trends. The near-term effect of the reduction in hydropower, should the new
30082 replacement resources not be built by 2022 as assumed, would likely be an increase in
30083 generation and emissions from existing fossil-fuel power plants.

30084 **Table 3-201. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple**
30085 **Objective Alternative 1, 2022**

Geographic Scope	Emissions Metric	No Action Alternative (NAA)	MO1 (Conventional Least-Cost Replacement)	MO1 (Zero-Carbon Replacement)
Pacific Northwest	Regional Annual Emissions (MMT CO ₂)	36.7	37.0	36.2
	Difference from NAA (MMT CO ₂)	–	0.34	-0.48
	Difference from NAA (%)	–	0.92	-1.3
Western Interconnection	Regional Annual Emissions (MMT CO ₂)	163	163	163
	Difference from NAA (MMT CO ₂)	–	0.66	-0.063
	Difference from NAA (%)	–	0.41	-0.04

30086 Note: Pacific Northwest estimates include Jim Bridger and half of the North Valmy 2 coal power plants. The
30087 conventional least-cost resource replacement portfolio relies primarily on natural gas generation to replace
30088 foregone hydropower, whereas the zero-carbon resource replacement portfolio relies primarily on generation
30089 from solar resources.

30090 Source: AURORA outputs; see Section 3.7, *Power Generation and Transmission*, for modeling approach.

30091 Like the No Action Alternative, emissions over time under MO1 remain relatively steady
30092 reflecting the NW Council forecast for generation over time (NW Council 2016b). The effects of
30093 MO1 on CO₂ emissions as compared with No Action Alternative remain modest over the
30094 20- year timeframe (1 percent increase in emissions assuming conventional least-cost natural
30095 gas replacement, and 1 percent decrease in emissions assuming zero-carbon renewable
30096 resource replacement), as highlighted in Table 3-202.

30097 **Table 3-202. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple**
30098 **Objective Alternative 1 (2022 to 2041)**

Alternative (Resource Replacement Portfolio)	Emissions (MMT CO ₂)				
	2022	2027	2032	2037	2041
No Action Alternative Total Emissions in the Pacific Northwest	36.7	36.6	36.5	36.5	36.5
MO1 (Conventional Least-Cost) Increase Relative to No Action Alternative	0.34 (0.9%)	0.37 (1.0%)	0.38 (1.0%)	0.39 (1.1%)	0.39 (1.1%)
MO1 (Zero-Carbon) Decrease Relative to No Action Alternative	-0.48 (-1.3%)	-0.45 (-1.2%)	-0.47 (-1.3%)	-0.48 (-1.3%)	-0.48 (-1.3%)

30099 As described in Section 3.7.3.2, the power analysis is sensitive to alternative assumptions
30100 regarding coal capacity in the region. Under a limited or no coal future, as described above, the
30101 emissions effects under MO1 relative to the No Action Alternative would depend on the nature
30102 of replacement resources (fossil fuel and renewable resources) for both the reduction in coal
30103 and the reduction in hydropower. If the reduction in coal were replaced by zero-carbon
30104 resources, emissions could decrease substantially; however, the amount of zero-carbon
30105 resources required would be very substantial, particularly due to the reduction in hydropower
30106 under MO1, as presented in Table 3-203. This analysis additionally considers potential
30107 emissions effects across the wider Western Interconnection area (excluding areas outside of
30108 the United States) due to the interconnectedness of the electricity markets (as described in
30109 Section 3.7.2). Average emissions reported by the AURORA model according to the
30110 conventional least-cost replacement portfolio for MO1 would be 156 MMT CO₂ across the
30111 Western Interconnection area; this would be a 0.4 percent increase as compared with No
30112 Action Alternative emissions over the same area. In the Western Interconnection area for the
30113 zero-carbon resource replacement portfolio, average emissions would be 155 MMT CO₂, an
30114 approximately 0.1 percent reduction in total emissions. The slightly more modest changes in
30115 emissions across the broader Western Interconnection area relative to the change in the Pacific
30116 Northwest indicate that the effects of MO1 are focused in the Pacific Northwest.

30117 **GHG Emissions from Navigation and Transportation under Multiple Objective Alternative 1**

30118 MO1 would not affect the level of barge transportation or river navigation in the region; thus,
30119 this analysis does not expect effects on navigation and transportation-related GHG emissions.
30120 As described in Section 3.10.3, changes to the cost of shipping on the Columbia and Snake
30121 Rivers under MO1 would be less than 1 percent, and the changes to river flows would be
30122 minimal.

30123 **GHG Emissions from Construction Activities under Multiple Objective Alternative 1**

30124 Construction activities associated both with the structural measures described under MO1 and
30125 construction of replacement resources for the reduction in hydropower generation have the
30126 potential to generate GHG emissions. The use of light- and heavy-duty vehicles and equipment
30127 rely on combustion of diesel fuel or gasoline.

30128 Emissions from construction and operations of power plants, when considered with the
30129 emissions resulting from power generation, are commonly referred to as “lifecycle” GHG
30130 emissions. For natural gas and other fossil fuels, lifecycle emissions are primarily from fuel
30131 combustion for power generation. However, for renewable energy resources that do not emit
30132 GHGs as a byproduct of power generation, overall lifecycle emissions are low and primarily
30133 linked to construction and other industrial processes to build the resource (NREL 2013).

30134 Overall, construction-related GHG emissions under MO1 would be short term (during the
30135 construction period) and minor as compared with the changes in emissions from power
30136 generation under this alternative.

30137 **Other GHG Emissions Sources under Multiple Objective Alternative 1**

30138 As previously described, the MOs would not affect reservoir methane emissions. Additionally,
30139 MO1 would not result in any changes in land use (e.g., conversion from inundated to vegetated
30140 landscapes) that would affect carbon sequestration potential of the landscape.

30141 **Meeting Emissions Reductions Targets under Multiple Objective Alternative 1**

30142 This analysis evaluates implications on emissions according to both the conventional least-cost
30143 and zero-carbon replacement portfolios. As previously described, recent and emerging policy
30144 focused on reducing energy-sector GHG emissions indicates that the zero-carbon resource
30145 replacement portfolio may better reflect future trends. The zero-carbon resource replacement
30146 portfolio would result in a very modest reduction in GHG emissions under MO1 relative to No
30147 Action Alternative, aiding the states and municipalities in achieving emission goals. However,
30148 this would also require more zero-carbon resource acquisitions for MO1 than for the No Action
30149 Alternative to achieve the states’ goals.

30150 **Social Cost of Carbon Effects under Multiple Objective Alternative 1**

30151 This analysis estimates the monetized value of the CO₂ emissions from power generation in
30152 term of the social costs (i.e., climate-related damages) of the marginal changes in atmospheric
30153 carbon. Under MO1, the conventional least-cost resource replacement portfolio (mostly natural
30154 gas generation) would result in a slight increase in CO₂ emissions relative to No Action
30155 Alternative, whereas the zero-carbon replacement portfolio (mostly solar generation) would
30156 result in a slight decrease in emissions.

30157 Assuming the zero-carbon replacement portfolio is reflective of future trends, the central
30158 estimate for the present value (2022 to 2041) of the reduced emissions benefit under MO1 is
30159 \$400 million (assuming a 3 percent discount rate in accordance with best practices) (IWG 2016).
30160 This equates to an annualized benefit of \$25 million. These benefits reflect the global reduction
30161 in climate-related damages associated with the expected reduction in GHG emissions under
30162 MO1 if the additional zero-carbon generation is constructed to replace lost hydropower
30163 generation. The SCC for the conventional least-cost replacement portfolio is presented in

30164 Table 3-203. Appendix G includes the calculation of the emissions and SCC values by year over
30165 the timeframe of the analysis.

30166 Table 3-203 presents a range of results reflecting alternative assumptions regarding the
30167 appropriate discount rate for discounting these types of intergenerational effects, as well as a
30168 portfolio that considers greater than expected (95th percentile) damages from climate change
30169 over time. Due to the considerable uncertainty inherent in the calculation of the SCC values, the
30170 results of the analysis according to all of these alternative assumptions are presented for
30171 consideration.

30172 **Table 3-203. Present Value and Annualized Values of Changes in CO₂ Emissions in the Pacific**
30173 **Northwest under Multiple Objective Alternative 1 Relative to No Action Alternative (2022 to**
30174 **2041, 2019 U.S. Dollars)**

Alternative (Resource Replacement Portfolio)		Social Cost of Carbon Values			
		5% Average	3% Average	2.5% Average	3% 95 th Percentile
MO1 (Conventional Least-Cost)	Total Present Value	\$82 million	\$320 million	\$500 million	\$980 million
	Annualized	\$6.3 million	\$21 million	\$31 million	\$64 million
MO1 (Zero-Carbon)	Total Present Value	-\$10 million	-\$400 million	-\$610 million	-\$1,200 million
	Annualized	-\$7.7 million	-\$26 million	-\$38 million	-\$79 million

30175 Note: These estimates reflect three different discount rates (the averages used by three different climate models)
30176 and a high estimate of the 95th percentile for potential lower-probability, high-impact outcomes to capture
30177 uncertainty. The central estimate is the 3 percent discount rate. All values in this table are rounded to two
30178 significant digits. Full values for each portfolio as well as the schedule for each discount rate SCC estimates are in
30179 Appendix G. Annualized values are calculated by first estimating the total present value of the future stream of
30180 costs and then calculating the annualized estimates (i.e., average annual equivalent) employing the same discount
30181 rate assumption.

30182 Source: IWG 2016: for SCC cost schedule over time, see Appendix G for full schedule.

30183 **SUMMARY OF EFFECTS**

30184 For all of the regions, air pollutant emissions from power generation would most likely be
30185 reduced as compared with No Action Alternative due to increased reliance on renewable
30186 resources and a reduction in fossil fuel generation (assuming zero-carbon resource
30187 replacement). Changes in emission from navigation and transportation and fugitive dust would
30188 be negligible relative to No Action Alternative. Construction-related emissions would be short
30189 term, and limited to the construction period. These effects are also localized at various CRS
30190 project sites, and potential construction sites for new power generating resources in uncertain
30191 locations. Further, in Region D, multiple structural projects at McNary may result in PM and
30192 other air pollutant emissions nearby an existing maintenance area for PM emissions, though
30193 the increased emissions are unlikely to exceed *de minimis* standards and risk the attainment
30194 status of this maintenance area. Overall, effects of MO1 on air quality would be generally
30195 negligible, except for minor short-term adverse effects in Region D by McNary Dam.

30196 If reduced hydropower generation is replaced with zero-carbon resources, then air pollutant
30197 emissions from power generation would most likely be reduced as compared with No Action
30198 Alternative due to increased reliance on renewable resources and a reduction in fossil fuel
30199 generation. This would result in a modest reduction in GHG emissions. If conventional least-cost
30200 resources, specifically gas-fired generation, replace reduced hydropower generation, then
30201 carbon emissions would likely increase slightly. Changes in emission from navigation and
30202 transportation would be negligible relative to No Action Alternative. Construction-related
30203 GHG emissions would increase under MO1, but that would be short-term (during the
30204 construction period) and very limited as compared with the reductions in emissions from power
30205 generation under this alternative. Overall, given the benefit associated with reduced GHG
30206 emissions effects of MO1, there would potentially be beneficial impacts to GHG emissions
30207 assuming a zero-carbon replacement portfolio ranging to minor adverse effects across the
30208 region.

30209 **3.8.3.4 Multiple Objective Alternative 2**

30210 **AIR POLLUTANTS AND AIR QUALITY UNDER MULTIPLE OBJECTIVE ALTERNATIVE 2**

30211 MO2 would increase hydropower generation thus reducing fossil fuel generation. These
30212 increases in hydropower are due to operational measures, such as ending summer spill in
30213 August. The increased hydropower generation would offset the need for fossil fuel generation,
30214 resulting in a lesser level of air pollutant emissions in the region relative to No Action
30215 Alternative. No construction of major replacement resource occurs, and structural measures
30216 would not generate major increases relative to No Action Alternative.

30217 Under MO2, effects to air quality are anticipated to be similar in the Canadian portions as those
30218 described for the United States. However, the effects would reduce as the geographic distance
30219 from the CRS projects increase.

30220 **Air Pollutant Emissions from Power Generation under Multiple Objective Alternative 2**

30221 No replacement power would be necessary under MO2 because this alternative results in
30222 improvements in system reliability. The increases in hydropower under MO2 would decrease
30223 natural gas and coal power generation relative to the No Action Alternative, reducing air
30224 pollutants. Overall, these changes would increase hydropower generation by approximately
30225 3 percent and reduce coal and natural gas by 56 average megawatts (aMW) and 190 aMW,
30226 respectively. This represents an approximately 5.7 percent decrease in coal and natural gas
30227 power generation.

30228 These changes in the fuel mix reduce air pollutant emissions from power generation.
30229 Reductions in SO₂ emissions (a common air pollutant generated from the combustion of coal
30230 and, to a lesser degree, natural gas) around the coal and gas plants is possible. These power
30231 plants are primarily located in Region D. The reduced air pollutant emissions from coal
30232 generation would occur outside of the Pacific Northwest, in Montana and eastern Wyoming

30233 where the Colstrip and Jim Bridger coal power plants are located.¹⁸ Locations are in proximity
30234 to nonattainment areas for PM (Colstrip) and O₃ (Jim Bridger). Thus, the reduction in air
30235 pollutant emissions in these areas may confer a benefit in helping meet and maintain NAAQS.

30236 **Air Pollutant Emissions from Navigation and Transportation under Multiple Objective**
30237 **Alternative 2**

30238 MO2 would not affect the level of barge transportation or river navigation in the region; thus, this
30239 analysis does not expect effects on navigation- and transportation-related air pollutant emissions.
30240 As described in Section 3.10.3, changes to the cost of shipping on the Columbia and Snake Rivers
30241 under MO2 would be less than 1 percent, and the changes to river flows would be minimal.

30242 **Air Pollutant Emissions from Construction Activities under Multiple Objective Alternative 2**

30243 Structural measures under MO2 include upgrading spillway weirs to adjustable spillway weirs,
30244 expanding lamprey structures, and installing pumps. The upgrading of spillway weirs occurs at
30245 five CRS projects, concentrated at McNary and John Day Dams. Other structural measures
30246 include building powerhouse and spill surface passage routes at the Ice Harbor, McNary, and
30247 John Day projects. Multiple modifications to existing projects also occur under MO2 and,
30248 though these are less intensive construction activities than upgrading or installing new facilities,
30249 they may also generate adverse pollutant effects relative to No Action Alternative. MO2 would
30250 not require any replacement power resources and therefore would not result in additional
30251 power plant construction activity, as compared with No Action Alternative.

30252 The construction activities in MO2 would occur primarily in Regions C and D, in proximity to the
30253 Wallula maintenance area for PM₁₀. Adoption of BMPs to reduce PM emissions from
30254 construction activities (as previously described) could mitigate adverse effects. Air pollutant
30255 emissions from construction activities under MO2 would have short-term, localized effects
30256 occurring during the period of construction at projects primarily in Regions C and D.

30257 **Other Air Pollutant Emissions Sources under Multiple Objective Alternative 2**

30258 Under MO2, due to increased draft for hydropower generation, elevations at multiple CRS
30259 projects would decrease compared to No Action Alternative, exposing additional shoreline.
30260 The River Mechanics analysis (Section 3.3.3.5) determined that the effects of these elevation
30261 changes would be negligible apart from at Dworshak Dam in Region C. Reservoir elevation
30262 levels at Dworshak Dam would change by more than 20 feet in March through May relative to
30263 the No Action Alternative. Under high temperature and wind, and low precipitation conditions,
30264 the exposed sediment may increase fugitive windblown dust and associated PM emissions.
30265 The average wind speeds and 95th percentile wind speeds for regional monitoring stations near
30266 Dworshak Dam are relatively low compared to the thresholds for wind erosion and high-wind

¹⁸ As described in the Methodology (Section 3.8.3.1) and in Section 3.7.3, this analysis reflects the closure of Colstrip units 1 and 2. For a full list of coal power plants included in the analysis, see Table 3-132 in Section 3.7.3.1.

30267 dust events, making the likelihood of fugitive dust emissions low. Appendix G provides more
30268 information on wind speeds and frequencies.

30269 The potential for increased dust at Dworshak may occur seasonally over the long term and may
30270 be mitigated, for example by watering these areas. The effects would be localized to the project
30271 site, which is not located near or within existing PM maintenance or nonattainment areas.
30272 Effects from potential windblown dust could affect the Nez Perce Tribe, as the Nez Perce
30273 Reservation is near Dworshak.

30274 **GREENHOUSE GAS EMISSIONS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 2**

30275 MO2 would result in additional hydropower generation as compared with No Action
30276 Alternative. The increased hydropower generation displaces fossil fuel-based generation
30277 resulting in a net decrease in GHG emissions from power generation relative to No Action
30278 Alternative. All other effects of MO2 would most likely be negligible relative to this decrease.

30279 **Greenhouse Gas Emissions from Power Generation under Multiple Objective Alternative 2**

30280 CO₂ emissions from power generation in the Pacific Northwest under MO2 would be 35.9 MMT
30281 CO₂ in 2022, a 2.2 percent reduction from No Action Alternative in that year. This beneficial
30282 effect of the alternative is due to more hydropower generation and less use of natural gas and
30283 coal relative to No Action Alternative. As MO2 would increase hydropower generation, it does
30284 not require replacement resources. Table 3-204 and Table 3-205 presents the total Pacific
30285 Northwest power generation-related emissions compared to No Action Alternative and
30286 identifies emissions effects of MO2 over the 20-year timeframe.

30287 **Table 3-204. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple**
30288 **Objective Alternative 2, 2022**

Geographic Scope	Emissions Metric	No Action Alternative (NAA)	MO2
Pacific Northwest	Regional Annual Emissions (MMT CO ₂)	36.7	35.6
	Difference from NAA (MMT CO ₂)	–	-1.1
	Difference from NAA (%)	–	-3.0
Western Interconnection	Regional Annual Emissions (MMT CO ₂)	163	161
	Difference from NAA (MMT CO ₂)	–	1.8
	Difference from NAA (%)	–	-1.1

30289 Note: Pacific Northwest estimates include Jim Bridger and half of the North Valmy 2 coal power plants. See
30290 footnote 16 for further description of these power plants .MO2 does not experience a loss of hydropower and
30291 does not have resource replacement portfolios. Therefore, this table presents only a single portfolio relative to No
30292 Action Alternative.

30293 Source: AURORA outputs; NW Council (2019)

30294 **Table 3-205. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple**
30295 **Objective Alternative 2 (2022 to 2041)**

Emissions by Alternative	Emissions (MMT CO ₂)				
	2022	2027	2032	2037	2041
No Action Alternative - Total Emissions in the Pacific Northwest	36.7	36.6	36.5	36.5	36.5
MO2 Decrease Relative to No Action Alternative	-1.1 (-3.0%)	-1.1 (-3.0%)	-1.1 (-3.0%)	-1.1 (-3.1%)	-1.1 (-3.1%)

30296 As described in Section 3.7.3.2, the power analysis is sensitive to alternative assumptions
30297 regarding future coal capacity in the region. Under a limited or no-coal future, the emissions
30298 effects under MO2 would depend on the nature of replacement resources (fossil fuel and
30299 renewable resources) for the reduction in coal. If the reduction in coal were replaced by zero-
30300 carbon resources, emissions could decrease substantially; however, the amount of zero-carbon
30301 resources required would be large (though relatively smaller than the No Action Alternative due
30302 to the increase in hydropower under MO2) as presented in Table 3-205 and 3-206. The increased
30303 hydropower generation under MO2 would offset at some level the need for additional zero-
30304 carbon resources in the region.

30305 Across the Western Interconnection, excluding regions outside of the United States, average
30306 emissions from AURORA under MO2 are 161 MMT CO₂, a 1.1 percent reduction from No Action
30307 Alternative. The more modest changes in emissions across the broader Western
30308 Interconnection area indicate that the effects of the alternative are focused in the Pacific
30309 Northwest.

30310 **Greenhouse Gas Emissions from Navigation and Transportation under Multiple Objective**
30311 **Alternative 2**

30312 MO2 does not affect the level of barge transportation or river navigation in the region; thus,
30313 this analysis does not expect effects on navigation- and transportation-related GHG emissions.
30314 As described in Section 3.10.3, changes to the cost of shipping on the Columbia and Snake
30315 Rivers under MO2 would be less than 1 percent, and the changes to river flows would be
30316 minimal.

30317 **Greenhouse Gas Emissions from Construction Activities under Multiple Objective Alternative**
30318 **2**

30319 GHG emissions from construction activities under MO2 would likely be negligible. MO2 includes
30320 some structural measures that would increase use of vehicles and equipment relative to No
30321 Action Alternative; however, this effect would be short term (during the construction period)
30322 and minor. Additionally, MO2 does not include construction of any replacement power
30323 generating resources.

30324 **Other Greenhouse Gas Emissions Sources under Multiple Objective Alternative 2**

30325 MO2 would not affect reservoir methane emissions. Additionally, MO2 would not result in any
30326 changes in land use (e.g., conversion from inundated to vegetated landscapes) that would
30327 affect carbon sequestration potential of the landscape.

30328 **Meeting Emissions Reduction Targets under Multiple Objective Alternative 2**

30329 MO2 would increase hydropower generation across the Pacific Northwest, reducing fossil fuel
30330 generation and associated emissions as compared with No Action Alternative. In particular,
30331 MO2 would be beneficial to GHG reduction targets that are consumption based, as it reduces
30332 emissions from high coal generation areas such as Montana and Wyoming. While Montana
30333 does not have a specific emissions target, much of the coal generation is exported to
30334 Washington and Oregon for consumers. In addition, while Oregon is not expected to meet
30335 short-term emissions targets, Oregon would experience the largest decreases in GHG emissions
30336 under MO2 of any Pacific Northwest state. The decrease would be very limited (0.1 MMT CO₂)
30337 at the state level. However, for municipalities such as Beaverton in Washington County and
30338 Portland in Multnomah County that have high targets by 2050, these emissions reductions may
30339 be meaningful since these municipalities' power is supplied by IOUs that currently have
30340 substantial fossil fuel generation in their portfolios.

30341 **Social Cost of Carbon Effects under Multiple Objective Alternative 2**

30342 MO2 would reduce emissions relative to No Action Alternative. Appendix G includes the
30343 calculation of the emissions and SCC values by year over the timeframe of the analysis.
30344 The central estimate for the present value (2022 to 2041) of the reduced emissions benefit
30345 under MO2 is \$950 million (assuming a 3 percent discount rate in accordance with best
30346 practices) (IWG 2016). This equates to an annualized benefit of \$62 million. These benefits
30347 reflect the global reduction in climate-related damages associated with the expected reduction
30348 in GHG emissions under MO2. While these values seem large, they reflect a relatively limited
30349 reduction in GHG emissions (3.0 percent) relative to No Action Alternative over the 20-year
30350 timeframe.

30351 Table 3-206 presents a range of results reflecting alternative assumptions regarding the
30352 appropriate discount rate for discounting these types of intergenerational effects, as well as a
30353 portfolio that reflects greater than expected (95th percentile) damages from climate change
30354 over time. Due to the considerable uncertainty inherent in the calculation of the SCC values, the
30355 results of the analysis according to these alternative assumptions are presented for
30356 consideration.

30357 **Table 3-206. Present Value and Annualized Values of Changes in CO₂ Emissions in the Pacific**
 30358 **Northwest under Multiple Objective Alternative 2 Relative to No Action Alternative (2022 to**
 30359 **2041, 2019 U.S. Dollars)**

Portfolio		Total Discounted SCC			
		Present Value 5% Average	Present Value 3% Average	Present Value 2.5% Average	Present Value 3% 95 th
MO2	Total	-\$240 million	-\$950 million	-\$1,500 million	-\$2,900 million
	Annualized	-\$18 million	-\$62 million	-\$91 million	-\$190 million

30360 Note: These estimates reflect three different discount rates (the averages used by three different climate models)
 30361 and a high estimate of the 95th percentile for potential lower-probability, high-impact outcomes to capture
 30362 uncertainty. The central estimate is the 3 percent discount rate. All values in this table rounded to two significant
 30363 digits. Full values for each portfolio as well as the schedule for each discount rate SCC estimates are in Appendix G.
 30364 Annualized values are calculated by first estimating the total present value of the future stream of costs and then
 30365 calculating the annualized estimates (i.e., average annual equivalent) employing the same discount rate assumption.
 30366 Source: IWG 2016; for SCC cost schedule over time, see Appendix G for full schedule

30367 **SUMMARY OF EFFECTS**

30368 For all regions, increased power generation from hydropower (no associated emissions) would
 30369 reduce generation from fossil fuels, leading to a reduction in emissions (including PM, NO_x, and
 30370 SO₂). Changes in emissions from navigation and transportation would be negligible relative to
 30371 No Action Alternative. MO2 includes a relatively low level of construction activity given no new
 30372 power generation resources would be needed to meet regional demand for power.

30373 In Region C, potential exists for seasonal, localized fugitive dust emissions at Dworshak over the
 30374 long term due to reduced water levels. However, these emissions would not be near or within
 30375 existing nonattainment or maintenance areas and may be mitigated by watering exposed
 30376 sediment and limiting vehicle use in the exposed sediment areas. Overall, effects of MO2 on air
 30377 quality would be minor beneficial across all regions with the exception of minor adverse effects
 30378 in Region C near Dworshak Dam.

30379 Increased power generation from hydropower (no associated emissions) would reduce
 30380 generation from fossil fuels, leading to a reduction in GHG emissions. Changes in emissions
 30381 from navigation and transportation, as well as construction activities, would be negligible
 30382 relative to No Action Alternative. Construction-related GHG emissions under MO2 would be
 30383 short term (during the construction period), and very limited as compared with the reductions
 30384 in emissions from power generation under this alternative. Overall, GHG emissions effects
 30385 would be beneficial and minor under MO2.

30386 **3.8.3.5 Multiple Objective Alternative 3**

30387 MO3 involves the breaching of the lower Snake River projects (Ice Harbor Dam, Lower
 30388 Monumental Dam, Little Goose Dam, and Lower Granite Dam). The breaching of these projects
 30389 would reduce hydropower generation, increasing regional air pollutant and GHG emissions.
 30390 MO3 also requires extensive deconstruction work that would create air pollutant emissions

30391 from construction activities and equipment. Compared to No Action Alternative, air pollutants
30392 and GHG emissions would increase under MO3.

30393 Under MO3, effects to air quality are anticipated to be similar in the Canadian portions as those
30394 described for the United States. However, the effects would reduce as the geographic distance
30395 from the CRS projects increase.

30396 **AIR POLLUTANTS AND AIR QUALITY UNDER MULTIPLE OBJECTIVE ALTERNATIVE 3**

30397 Under MO3, air pollutant emissions would increase from the energy sector regardless of the
30398 resource replacement portfolio. Additionally, construction activities and exposed shoreline
30399 sediment under MO3 would affect air pollutant emissions and may result in negative effects on
30400 air quality under MO3 as compared to No Action Alternative. The breaching of the lower Snake
30401 River projects is the primary measure affecting air pollutants.

30402 **Air Pollutant Emissions from Power Generation under Multiple Objective Alternative 3**

30403 With the foregone power generation from the lower Snake River projects, hydropower
30404 generation would decrease by 9 percent relative to No Action Alternative. Emissions would
30405 increase under both the conventional least-cost and zero-carbon replacement portfolios.
30406 The conventional least-cost resource replacement portfolio would result in additional natural
30407 gas and coal power generation in the Pacific Northwest, an increase of 28 percent and
30408 7 percent, respectively. The zero-carbon resource replacement portfolio would include
30409 considerable additional generation from solar resources; however, the level of solar included
30410 does not enable the system to meet demand at all times (e.g., during peak demand).
30411 Consequently, even under the zero-carbon replacement portfolio, gas generation would
30412 increase by 3 percent and coal by 8 percent, resulting in additional air pollutant emissions from
30413 these sources.¹⁹ In addition, any additional fossil fuel generation would be subject to and
30414 controlled by the applicable emissions permitting and regulation as described in Section 3.8.1.
30415 The potential exists for changes to affect regional haze and deterioration of air quality even if
30416 new emissions do not violate these standards. Chapter G-4 of Appendix G describes regional
30417 haze in further detail.

30418 The increased air pollutant emissions under MO3 relative to No Action Alternative, particularly
30419 NO_x emissions, would most likely be concentrated in Region D in Oregon, where the natural gas
30420 power plants may be located (Section 3.7, *Power Generation and Transmission*).

30421 The large increase in natural gas-based power production in these areas would be a concern
30422 mainly due to NO_x emissions. These emissions could pose a risk to air quality by increasing
30423 concentrations of NO₂ in the local vicinity. Also, NO_x is a precursor to PM_{2.5} and ozone. No areas
30424 in the near vicinity of Region D are currently out of attainment for NO₂, PM_{2.5}, or O₃; thus, the

¹⁹ The AURORA model results indicate more coal generation under the zero-carbon replacement scenario than the conventional least-cost replacement scenario. This is likely because, while the replacement resources under the zero-carbon scenario are renewables (and demand response), the systemwide generation to meet load includes variable levels of fossil fuels depending on the timing of demand.

30425 EPA *de minimis* standards are not relevant. However, increased concentrations of these
30426 pollutants may pose a risk to air quality and contribute to regional haze and PSD increment
30427 consumption. MO3 would result in adverse effects to air quality near tribal lands due to dam
30428 breaching and an increased reliance on coal or natural gas. This would be less if the output of
30429 the Snake River dams was replaced with renewable energy.

30430 In addition, any additional fossil fuel generation would have to follow the applicable emissions
30431 permitting and regulations, including evaluating and addressing potential effects on Class I
30432 areas. Chapter G-4 of Appendix G describes Class I areas in further detail, as well as providing a
30433 map of Class I areas in the Pacific Northwest.

30434 The increased air pollutant emissions from coal would occur around the coal plants in Montana
30435 and Wyoming, which are adjacent to nonattainment areas for PM and O₃, respectively. Coal
30436 power generation generates O₃ precursors and can also create secondary PM emissions, and
30437 SO₂ and NO_x can generate secondary PM when reacting in the atmosphere (Oak Ridge National
30438 Laboratory 2017). The additional emissions from coal generation in these areas may exceed *de*
30439 *minimis* levels of PM or O₃ precursor emissions (100 tons per year) for nonattainment areas,
30440 and may adversely affect regional compliance with NAAQS. Section 3.8.1 provides additional
30441 discussion of *de minimis* levels and conformity regulations.

30442 **Air Pollutant Emissions from Navigation and Transportation under Multiple Objective**
30443 **Alternative 3**

30444 MO3 involves major changes to river navigation in the lower Snake River within the Columbia
30445 River Basin Region C due to the breaching of the four lower Snake River projects, which would
30446 limit barge-based freight transportation on the lower Snake River. As described in Section
30447 3.10.3, expected maximum water depth in the river is reduced under MO3, making the lower
30448 Snake River inaccessible to navigation. The analysis identifies a shift in freight transport in
30449 Region C from relatively low emissions barge-based transport to higher emissions rail- and
30450 truck-based transport. Specifically, Section 3.10.3 identifies an increase in rail freight (measured
30451 in total ton-miles) of up to 86 percent and in truck freight of up to 19 percent; if a rail rate (rail
30452 cost) increase were to occur due to the increased demand on rail freight, additional freight
30453 shifts to trucks and may increase truck freight by up to 84 percent relative to No Action
30454 Alternative.²⁰

30455 These modal transportation changes would likely lead to an increase in air pollutant emissions,
30456 specifically HAPs, VOCs, CO, PM, and NO_x, from rail and truck transportation under MO3
30457 relative to No Action Alternative. The changes in these emissions would be very small relative
30458 to total transportation-related air pollutants in the region.

²⁰ The CRSO Navigation analysis (Section 3.10.3) considers three dam breach navigation scenarios under MO3: no rail rate increase, a 25 percent rail rate increase, and a 50 percent increase. This analysis presents the no rail rate and 50 percent rail rate scenarios as the high and low of these scenarios.

30459 The adverse effects on air pollutant emissions are likely long term and focused within Region C.
30460 The area of increased emissions in the lower Snake River overlaps maintenance areas in
30461 Washington and Oregon. The Wallula, Washington, maintenance area for PM₁₀ is close to the
30462 lower Snake River. While nearby Union County in Oregon is also a maintenance area for PM₁₀,
30463 the modal changes towards truck-based transport under MO3 most likely affects Washington
30464 and not Oregon (Section 3.10, *Navigation and Transportation*). Given that PM emissions rates
30465 are low for all modes (from 0.05 to 0.005 grams per ton-mile), it is unlikely that there is the
30466 potential for increased emissions to cross *de minimis* thresholds for PM emissions (100 tons per
30467 year) for maintenance areas. Increased air pollutants from moving goods that would have been
30468 barged would impact air quality near tribal lands along the Columbia River and could have
30469 adverse effects to tribes near the Lower Snake River dams, such as the Confederated Tribes of
30470 the Umatilla Indian Reservation and Nez Perce Tribe.

30471 Given the potential effects of vehicle emissions on haze, this analysis considered whether the
30472 increased transportation emissions would affect sensitive areas, such as the Columbia Gorge
30473 National Scenic Area, a protected natural scenic area that runs 83 miles along the Columbia
30474 River, covering six counties in southern Washington and northern Oregon. The National Scenic
30475 Area Act of 1986 requires the protection and improvement of resources of the Gorge.
30476 The concern for air pollutants and emissions in this area are haze pollution and visibility issues
30477 given the recreational and scenic value of the area, as well as the potential for HAPs given the
30478 mixed use (e.g., forest, urban) of the scenic area.

30479 Previous air quality studies of the Gorge Area identified on-road vehicles as one of many causes
30480 for regional haze (ODEQ 2011). Under MO3 modal transportation changes would occur,
30481 potentially diverting some barge freight onto additional trains or trucks. However, this analysis
30482 finds that these effects would be unlikely to occur in the near vicinity of the Gorge, but rather
30483 focused around the lower Snake River. Given this, it is unlikely that the increased truck
30484 transportation activity under MO3 would affect haze within the National Scenic Area. Chapter
30485 G-4 of Appendix G describes Class I areas in further detail as well as providing a map of Class I
30486 areas in the Pacific Northwest.

30487 **Air Pollutant Emissions from Construction Activities under Multiple Objective Alternative 3**

30488 The breaching of the four lower Snake River dams would involve construction activities, such as
30489 bulldozing and hauling to remove the embankments and certain structures surrounding the
30490 dams. These activities generate PM and other air pollutants from the operations of vehicles and
30491 equipment and there would be the potential for the suspension of dust from these activities by
30492 wind to affect neighboring areas.

30493 In addition to dam breaching, MO3 includes upgrades to spillway weirs at McNary and John Day
30494 Dams. As with two of the other alternatives, the construction of new power-generating
30495 infrastructure to replace the reduction in hydropower generation would contribute to
30496 construction-related air pollutant emissions in the short term. The location of potential new
30497 resources is uncertain.

30498 The timing of the projects would determine the magnitude of effects in the lower Snake River
30499 region. As presented in the description of alternatives, currently dam breaching would be in
30500 two phases starting with Lower Granite and Little Goose Dams, then Lower Monumental and
30501 Ice Harbor Dams. Given this focused construction activity on the lower Snake River in Region C,
30502 there is the potential for adverse effects on two maintenance areas for PM. Closest to the lower
30503 Snake River is the Wallula area in Washington and south, in Oregon, is the Union County
30504 maintenance area. Whether the additional PM emissions would exceed *de minimis* levels in
30505 these areas is uncertain. However, the effects would be short term and employing BMPs
30506 (as previously described) for these construction sites could mitigate potential adverse effects
30507 from construction activities. These construction-related effects could have short-term, adverse
30508 effects to tribes near the Lower Snake River dams, such as the Confederated Tribes of the
30509 Umatilla Indian Reservation and Nez Perce Tribe.

30510 **Other Air Pollutant Emissions Sources under Multiple Objective Alternative 3**

30511 Dam breach in MO3 would affect the conditions of the Snake River, including the width and
30512 elevation, as well as effects on two other CRS projects. The changes in elevation along the
30513 Snake River would be nearly 100 feet in certain areas and times of year. Changes in width
30514 would be the largest close to the dam breach sites, reducing width by up to 3,000 feet at Ice
30515 Harbor and Little Goose Dams.

30516 These changes would result in exposed riverbed that is no longer submerged under the
30517 reservoirs, and increased potential for erosion and suspension of dust by wind, generating
30518 PM emissions. These changes would occur over time following the breaching of the various
30519 projects. The resulting potential for fugitive dust depends on a variety of factors including
30520 precipitation, wind, and temperature. Wind speeds at the Walla Walla and Tri Cities monitoring
30521 stations average roughly 8 miles per hour with few instances above high-wind event thresholds
30522 (i.e., 90 percent of recorded days were below 20 miles per hour). Appendix G provides more
30523 information on wind speeds and frequencies.

30524 Over time, the risk of fugitive dust likely declines as vegetation covers the exposed sediment,
30525 reducing the potentially erodible area. Additionally, potential effects may be mitigated by
30526 planting of vegetation, restrictions on activities on the sediment such as recreation and use of
30527 vehicles, or by use of wind barriers for recreation areas.

30528 Human populations exposed to “dust bowls” are at higher risk of adverse health effects from
30529 dust. Areas that have historically experienced dust bowl exposures include Spokane, Pullman,
30530 and Colfax in eastern Washington. In addition, the Wallula maintenance area for PM₁₀ is located
30531 at the confluence of the Columbia and Snake Rivers. The most recent exceedance events in the
30532 Wallula maintenance area all exceeded speeds of 29 miles per hour, which is well above
30533 recorded average wind speeds. However, without mitigation, there is the potential for
30534 windblown dust from the banks of the Snake River to increase PM emissions near this
30535 maintenance area in Region C, risking its ability to meet the NAAQS for PM.

30536 GREENHOUSE GAS EMISSIONS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 3

30537 MO3 would have a larger effect on GHG emissions relative to the No Action Alternative, MO1,
30538 and MO2. While the dam breaching included in this alternative would affect GHG emissions due
30539 to shifts in river-based navigation and construction activities, the dominant effect is the
30540 increased GHG emissions from power generation as compared with No Action Alternative.

30541 Greenhouse Gas Emissions from Power Generation under Multiple Objective Alternative 3

30542 CO₂ emissions in the Pacific Northwest from power generation under the MO3 conventional
30543 least-cost resource replacement portfolio would be 39.9 MMT CO₂ in 2022, approximately a
30544 9 percent increase as compared with No Action Alternative in that year. Assuming the zero-
30545 carbon resource replacement, estimated emissions would be 37.7 MMT CO₂ in 2022 across the
30546 Pacific Northwest a 2.7 percent increase relative to the No Action Alternative. Given that policy
30547 and legislative decisions in Oregon and Washington are targeting large reductions in GHG
30548 emissions, a 2.7 percent increase in CO₂ emissions, even with the zero-carbon replacement
30549 resources, makes these goals more difficult to achieve.

30550 Table 3-207 and Table 3-208 presents the total Pacific Northwest and Western Interconnection
30551 power generation-related emissions compared to No Action Alternative. Even under the zero-
30552 carbon resource replacement portfolio, MO3 would increase CO₂ emissions. This is because,
30553 even with considerable future construction of new renewables capacity, the level of reduction
30554 in hydropower generation means there are particular times seasonally or even daily
30555 (e.g., during peak demand) during which more flexible fossil fuel generation would be
30556 dispatched to meet demand over the timeframe of the analysis. In addition, the near-term
30557 effect of the reduction in hydropower, should the new replacement resources not be built by
30558 2022 as assumed, would likely be a larger increase in power generation and emissions from
30559 existing fossil-fuel power plants to meet demand.

**30560 Table 3-207. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple
30561 Objective Alternative 3, 2022**

Geographic Scope	Emissions Metric	No Action Alternative (NAA)	MO3 (Conventional Least-Cost Replacement)	MO3 (Zero-Carbon Replacement)
Pacific Northwest	Regional Annual Emissions (MMT CO ₂)	36.7	39.9	37.7
	Difference from NAA (MMT CO ₂)	–	3.3	1.0
	Difference from NAA (%)	–	8.9	2.7
Western Interconnection	Regional Annual Emissions (MMT CO ₂)	163	166	165
	Difference from NAA (MMT CO ₂)	–	2.9	2.2
	Difference from NAA (%)	–	1.8	1.3

30562 Note: Pacific Northwest estimates include Jim Bridger and half of the remaining North Valmy coal power plant
30563 emissions. See footnote 16 for further description of these power plants. The conventional least-cost resource
30564 replacement portfolio relies primarily on natural gas generation to replace the reduction in hydropower, whereas
30565 the zero-carbon resource replacement portfolio relies primarily on generation from solar resources.

30566 Source: AURORA outputs and NW Council (2019)

30567 As described in Section 3.8.3.2, the power analysis is sensitive to alternative assumptions
30568 regarding coal capacity in the region. Under a limited or no coal future, the emissions effects
30569 under MO3 would depend on the nature of replacement resources (fossil fuel and renewable
30570 resources). If the reduction in coal were replaced by zero-carbon resources, emissions could
30571 decrease substantially; however, the amount of zero-carbon resources required would be very
30572 large, and even more substantial with the added effect of the reduction in hydropower under
30573 MO3, as presented in Table 3-208.

30574 **Table 3-208. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple**
30575 **Objective Alternative 3 (2022 to 2041)**

Alternative (Resource Replacement Portfolio)	Emissions (MMT CO ₂)				
	2022	2027	2032	2037	2041
No Action Alternative Total Emissions in the Pacific Northwest	36.7	36.6	36.5	36.5	36.5
MO3 (Conventional Least-Cost) Increase Relative to No Action Alternative	3.3 (8.9%)	4.1 (11%)	4.3 (12%)	4.4 (12%)	4.4 (12%)
MO3 (Zero-Carbon) Increase Relative to No Action Alternative	1.0 (2.7%)	1.2 (3.3%)	1.2 (3.3%)	1.2 (3.3%)	1.2 (3.3%)

30576 Across the wider Western Interconnection, excluding regions outside of the United States,
30577 average emissions from AURORA in MO3 with the conventional least-cost replacement
30578 portfolio would be 166 MMT CO₂, approximately 2 percent greater than No Action Alternative.
30579 Under the zero-carbon resource replacement portfolio, average emissions would be 165 MMT
30580 CO₂, 1.3 percent greater than No Action Alternative. The more modest changes in emissions
30581 across the broader Western Interconnection area indicate that the effects of the alternative are
30582 focused in the Pacific Northwest under MO3.

30583 **Greenhouse Gas Emissions from Navigation and Transportation under Multiple Objective**
30584 **Alternative 3**

30585 Due to the dam breach under MO3, barge-based freight transportation of wheat on the lower
30586 Snake River would become inoperable and total barge transport (from farms in Region C to
30587 Portland in Region D) of wheat would fall by 64 percent (as discussed in Section 3.10,
30588 *Navigation and Transportation*). As a result of the loss of barge transport, truck- and rail-based
30589 freight transportation increase. As truck and rail transportation are associated with higher
30590 emissions per ton-mile than barges, this results in a net increase in CO₂ emissions in 2022 of
30591 approximately 17 percent as compared with No Action Alternative.

30592 If, in addition to dam breaching, rail rates increase (as discussed in Section 3.10.3), freight
30593 transportation modes may shift away from rail. Under MO3 with a rail rate increase, CO₂
30594 emissions may be up to 53 percent higher than No Action Alternative due to increased levels of
30595 truck freight transportation.²¹ Table 3-209 summarizes the emissions by mode and the

²¹ The CRSO Navigation analysis (Section 3.10.3) considers three dam breach navigation scenarios under MO3: no rail rate increase, a 25 percent rail rate increase and a 50 percent increase. This analysis presents the no rail rate and 50 percent rail rate scenarios as the high and low of these scenarios.

30596 difference from No Action Alternative. The increased CO₂ emissions from navigation and
30597 transportation under MO3 are modest as compared with the increased CO₂ emissions from
30598 power generation.

30599 **Table 3-209. Navigation CO₂ Emissions by Type under Multiple Objective Alternative 3 and No**
30600 **Action Alternative in 2022 (MMT CO₂)**

Emissions (MMT CO ₂) by Freight Transportation Mode	No Action	MO3, No Rail Rate Increase	MO3 with 50% Rail Rate Increase
Truck	0.071	0.085	0.13
Rail	0.017	0.032	0.017
Barge	0.017	0.0061	0.013
Total	0.11	0.12	0.16
Difference from NAA (MMT CO ₂)	–	0.017	0.056
Difference from NAA (%)	–	17	53

30601 Note: The emissions presented here are only CO₂, not equivalents, and are for the year 2022. The emissions
30602 estimates derive from changes in modal freight transportation analyzed in Section 3.10 and from emissions factors,
30603 by mode, presented in the Affected Environment (Section 3.8.2) from Kruse, Warner, and Olson (2017).

30604 **Greenhouse Gas Emissions from Construction Activities under Multiple Objective Alternative**
30605 **3**

30606 The construction vehicles and equipment used in dam-breaching activities along the lower
30607 Snake under MO3 would generate GHG emissions from the burning of fuel. In addition,
30608 construction of replacement resources to offset the reduction in hydropower generation under
30609 MO3 would result in short-term GHG emissions effects. These effects are short term, occurring
30610 during the construction period, and very modest as compared with the power generation-
30611 related GHG emissions under MO3.

30612 **Other Greenhouse Gas Sources under Multiple Objective Alternative 3**

30613 MO3 would change the landscape around the lower Snake, exposing considerable shoreline
30614 area. To the extent that these areas are vegetated (either for mitigation or over time via natural
30615 succession), there may be increased levels of landscape carbon sequestration storage in the
30616 biomass and soil. However, this benefit of removing carbon from the atmosphere would be
30617 very modest relative to the increased carbon emissions from power generation under MO3.

30618 **Meeting Emissions Reductions Targets under Multiple Objective Alternative 3**

30619 Under MO3, assuming the zero-carbon portfolio, CO₂ emissions would increase relative to
30620 No Action Alternative. The emissions increases would occur in Montana due to increased coal
30621 generation, which would affect regions with consumption-based targets that rely on Montana
30622 coal generation. While this coal generation may still be sold in some areas, after 2025 no coal
30623 related power costs can be included in retail customer rates in Washington State, and penalties
30624 apply after 2030 due to the Washington Clean Energy Transformation Act. Similarly, after 2030,

30625 no coal power costs can be included in retail customer rates in Oregon due to the Oregon Clean
30626 Electricity and Coal Transition Act (2016).

30627 **Social Cost of Carbon Effects under Multiple Objective Alternative 3**

30628 MO3 would increase GHG emissions relative to No Action Alternative. This analysis evaluates
30629 implications on emissions according to both the conventional least-cost and zero-carbon
30630 replacement portfolios. As previously described, recent and emerging policy focused on
30631 reducing energy sector GHG emissions indicates that the zero-carbon resource replacement
30632 portfolio may better reflect future trends. Appendix G includes the calculation of the emissions
30633 and SCC values by year over the timeframe of the analysis.

30634 The central estimate for the present value of the increased climate-related damages under
30635 MO3 is \$1.0 billion (assuming a 3 percent discount rate in accordance with best practices)
30636 (IWG 2016) and assuming the additional zero-carbon generation is constructed to replace lost
30637 hydropower generation. This equates to an annualized cost of \$68 million relative to No Action
30638 Alternative. These costs reflect the global increase in climate-related damages associated with
30639 the expected marginal increase in GHG emissions under MO3. These values reflect a
30640 3.0 percent increase in GHG emissions relative to the No Action Alternative over the 20-year
30641 timeframe.

30642 Table 3-210 presents a range of results reflecting alternative assumptions regarding the
30643 appropriate discount rate for discounting these types of intergenerational effects, as well as a
30644 portfolio that reflects greater than expected (95th percentile) damages from climate change
30645 over time. Due to the considerable uncertainty inherent in the calculation of the SCC values, the
30646 results of the analysis according to these alternative assumptions are presented for
30647 consideration.

30648 **Table 3-210. Present Value and Annualized Values of Changes in CO₂ Emissions in the Pacific**
30649 **Northwest under Multiple Objective Alternative 3 Relative to No Action Alternative (2022 to**
30650 **2041, 2019 US Dollars)**

Alternative (Resource Replacement Portfolio)		Total Discounted SCC			
		Present Value 5% Average	Present Value 3% Average	Present Value 2.5% Average	Present Value 3% 95 th
MO3 (Conventional Least-Cost)	Total	\$910 million	\$3,600 million	\$5,500 million	\$11,000 million
	Annualized	\$69 million	\$230 million	\$340 million	\$710 million
MO3 (Zero-Carbon)	Total	\$260 million	\$1,000 million	\$1,600 million	\$3,100 million
	Annualized	\$20 million	\$68 million	\$99 million	\$200 million

30651 Notes: These estimates reflect three different discount rates (the averages used by three different climate models)
30652 and a high estimate of the 95th percentile for potential lower-probability, high-impact outcomes to capture
30653 uncertainty. The central estimate is the 3 percent discount rate. All values in this table rounded to two significant
30654 digits. Full values for each portfolio as well as the schedule for each discount rate SCC estimates are in Appendix G.
30655 Annualized values are calculated by first estimating the total present value of the future stream of costs, and then
30656 calculating the annualized estimates (i.e., average annual equivalent) employing the same discount rate assumption.
30657 Source: IWG (2016); for SCC cost schedule over time, see Appendix G for full schedule

30658 **SUMMARY OF EFFECTS**

30659 Long-term adverse effects related to reductions in hydropower generation would lead to
30660 increased fossil fuel generation and associated emissions. Increased natural gas generation
30661 would be likely to increase emissions of NO_x in Region D in Oregon, and coal generation in
30662 Wyoming and Montana, would increase emissions of SO₂, NO_x, PM, HAPs, and VOCs. The coal
30663 plants are near existing nonattainment areas for PM and O₃ and the additional emissions from
30664 coal have the potential to exceed *de minimis* levels of PM emissions, potentially affecting
30665 compliance with NAAQS. Exposed riverbed along the Snake River would increase potential for
30666 fugitive dust emissions in Region C. The associated PM emissions would occur adjacent to an
30667 existing maintenance area for PM (Wallula), risking the ability of this area to maintain
30668 adherence to NAAQS for PM. Overall, the effects of MO3 on air quality would most likely be
30669 moderate and adverse over the short and long term, primarily in Regions C and D and outside
30670 of the Pacific Northwest in areas of Montana and Wyoming.

30671 Over the 20-year timeframe, the analysis identifies increased power generation from fossil
30672 fuels, including both coal and natural gas, even under the zero-carbon resource replacement
30673 portfolio. Long-term adverse effects on GHG emissions would also be associated with modal
30674 shifts in freight transport along the lower Snake River from barge to relatively high emissions
30675 rail and truck. The increased emissions would be minor relative to the power generation-
30676 related emissions. Construction activities, including dam breaching and construction of
30677 replacement power resources, would generate emissions. These are likely short term (during
30678 the period of construction). Overall, effects of MO3 on GHG emissions would be minor and
30679 adverse over the short term, and moderate and adverse over the long term.

30680 **3.8.3.6 Multiple Objective Alternative 4**

30681 MO4 includes various structural and operational measures that would affect flow levels along
30682 the Columbia and Snake Rivers. Structural measures, such as modifications for spillways and
30683 other upgrades at the CRS projects, would require construction that creates GHG emissions and
30684 air pollutants. Various operational changes to spill, and changes to flow measures, would also
30685 affect hydropower generation. These measures in MO4 would reduce hydropower generation
30686 and affect navigation.

30687 Under MO4, effects to air quality are anticipated to be similar in the Canadian portions as those
30688 described for the United States. However, the effects would reduce as the geographic distance
30689 from the CRS projects increase.

30690 **AIR POLLUTANTS AND AIR QUALITY EFFECTS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 4**

30691 Under MO4, air pollutant emissions would increase from the power generation, construction
30692 activities, and exposed reservoir sediment under MO4. The air quality effects from construction
30693 and exposed sediments would most likely be localized to the project site and short term
30694 (occurring during the construction period).

30695 **Air Pollutant Emissions from Power Generation under Multiple Objective Alternative 4**

30696 Under MO4, hydropower generation would decrease by 10 percent relative to No Action
30697 Alternative, resulting in the need for replacement generation to meet the demand for power.
30698 For both the conventional least-cost and zero-carbon portfolios, fossil fuel generation would
30699 increase. For the conventional least-cost portfolio, natural gas generation would increase by 15
30700 percent and coal generation by 11 percent. These increases would lead to additional SO₂ and
30701 NO_x emissions and HAPs and VOC emissions, as well as PM increases from the coal generation.
30702 For the zero-carbon replacement portfolio, natural gas would decrease by 2 percent relative to
30703 No Action Alternative, but coal power increases 6 percent, increasing overall air pollutant
30704 emissions. This increase in air pollutant emissions is due to the fact that fossil fuel generation
30705 increases when solar power generation cannot meet demand. MO4 would result in adverse
30706 effects to air quality near tribal lands due to an increased reliance on coal or natural gas. This
30707 effect would be less if the change in hydropower generation was replaced with renewable
30708 energy.

30709 Any additional fossil fuel generation would be subject to and controlled by the applicable
30710 emissions permitting and regulation as described in Section 3.8.1. There is still the potential for
30711 changes to affect regional haze and deterioration of air quality even if new emissions do not
30712 violate these standards. Chapter G-4 of Appendix G describes regional haze in further detail.

30713 The increase in coal power generation would result in air pollutant emissions around coal
30714 power plants in Montana. Coal power generation can also create PM emissions and SO₂, and
30715 NO_x can generate secondary PM when decomposing in the atmosphere (Oak Ridge National
30716 Laboratory 2017). In Montana, coal power plant locations are in proximity to nonattainment
30717 areas for PM and the additional emissions may exceed EPA *de minimis* levels. The increase in
30718 natural gas generation would result in increased emissions in Region D in Oregon; however,
30719 under the zero-carbon resource replacement portfolio, these increases would be negligible.

30720 **Air Pollutant Emissions from Navigation and Transportation under Multiple Objective**
30721 **Alternative 4**

30722 MO4 would slightly increase costs for deep draft navigation traffic below Portland, Oregon
30723 (in Region D), and slightly decrease costs for shallow draft traffic from Portland to McNary Dam,
30724 as well as on the Snake River (Regions C and D). As described in Section 3.10.3, the increased
30725 costs for deep draft traffic may result in “light loading” vessels, requiring more trips to
30726 transport the same amount of freight, and a small increase in the number of tug operations.
30727 Conversely, shallow draft traffic in Regions C and D would experience very slight reduction in
30728 costs (0.1 percent) in comparison to No Action Alternative.

30729 The slight increase in shipping activity (i.e., barge trips) may result in a slight increase in
30730 emissions under MO4 relative to No Action Alternative in the long term. This analysis expects
30731 this would be low intensity and occurring within Regions C and D.

30732 **Air Pollutant Emissions from Construction Activities under Multiple Objective Alternative 4**

30733 Multiple structural measures under MO4 involve construction activities across the CRS projects,
30734 including additional fish passage routes, installing pumps and pipes, and upgrading turbines.
30735 The construction of additional powerhouse surface passage routes would occur at six projects:
30736 McNary, Little Goose, Lower Monumental, Bonneville, The Dalles, and Ice Harbor. The other
30737 structural measures involve primarily updating or modifying existing structures at projects
30738 including fish ladders and spillway weir notch inserts. The magnitude of these construction
30739 activities varies but all would require machinery and equipment, as well as vehicle travel to the
30740 site, which would increase air pollutants, especially PM, relative to No Action Alternative.
30741 In addition to construction for these powerhouse structural changes, construction of
30742 replacement power resources also emits localized air pollutants, though the location of these
30743 resources is uncertain.²²

30744 The CRS projects involved in the MO4 structural measures occur within Regions C and D.
30745 Activities at McNary and Ice Harbor Dams are close to the Wallula maintenance area for PM₁₀.
30746 However, as with the previously mentioned alternatives, air pollutant effects from construction
30747 would be localized and short term, and may be mitigated with application of BMPs.

30748 **Other Air Pollutant Emissions Sources under Multiple Objective Alternative 4**

30749 Under MO4, water surface elevation at multiple CRS projects would decrease compared to No
30750 Action Alternative, exposing additional shoreline. The River Mechanics analysis (Section 3.3.3.5)
30751 determined that the effects of these elevation changes were negligible apart from Hungry
30752 Horse Dam in Region A. Reservoir elevation levels at Hungry Horse experience a 2-foot
30753 reduction in all months except June and July relative to No Action Alternative.

30754 Under high temperature and wind, and low precipitation conditions, the exposed sediment may
30755 increase fugitive windblown dust and associated PM emissions. Generally, the wind speeds at
30756 the nearest monitoring station in Kalispell are low with average speeds of 5 miles per hour and
30757 very rare occurrences of high-wind speed events (0.5 percent of recorded hourly data).
30758 Appendix G provides more information on wind speeds and frequencies. The potential for
30759 increased dust at Hungry Horse may occur seasonally over the long term and may be mitigated
30760 by planting vegetation or restrictions on activities on the sediment, such as recreation and use
30761 of vehicles. The effects would be local to the project site, which is located within a county that
30762 includes nonattainment areas for PM at Columbia Falls and Whitefish, Montana, (EPA 2019).
30763 Given the seasonal variation in water levels and potential for mitigation, such as vegetation
30764 planting, to avoid adverse effects, the likelihood that fugitive dust emissions would affect the
30765 current nonattainment areas is low.

²² To the extent this analysis identifies potential resource replacement needs, additional site-specific planning, analysis, and compliance with environmental laws, including NEPA, would be required.

30766 **GREENHOUSE GAS EMISSIONS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 4**

30767 The effects of MO4 on GHG emissions would be similar to MO3. Both alternatives would result
30768 in a considerable reduction in hydropower generation which would be, to some extent,
30769 replaced by fossil fuel generation that results in increased CO₂ emissions even under the zero-
30770 carbon resource replacement portfolio. This is the dominant effect of MO4 on GHG emissions
30771 under this alternative.

30772 **Greenhouse Gas Emissions from Power Generation under Multiple Objective Alternative 4**

30773 Power generation-related GHG emissions in the Pacific Northwest under MO4, assuming
30774 conventional least-cost resource replacement, would be 39.8 MMT CO₂ in 2022, 8.4 percent
30775 greater than No Action Alternative for that year. Assuming the zero-carbon resource
30776 replacement portfolio, emissions would be 37.0 MMT CO₂ in 2022, 0.8 percent greater than
30777 No Action Alternative. For similar reasons as described for MO3, some level of fossil fuel-based
30778 generation is likely to offset the reduction in hydropower generation. Table 3-211 presents the
30779 total power emissions for MO4 compared to No Action Alternative. Given that policy and
30780 legislative decisions in Oregon and Washington are targeting large reductions in GHG emissions,
30781 a 2 percent increase in emissions, even with the zero-carbon replacement resources, makes
30782 these goals more difficult to achieve.

30783 Table 3-212 identifies the changes in emission under MO4 relative to No Action Alternative over
30784 the 20-year timeframe. The emissions effect of MO4 as compared with No Action Alternative
30785 would be relatively consistent over time. As previously described, recent and emerging policy
30786 focused on reducing energy-sector GHG emissions indicates that the zero-carbon resource
30787 replacement portfolio may better reflect future trends. However, the near-term effect of the
30788 reduction in hydropower, should the new replacement resources not be built by 2022 as
30789 assumed, would likely be an increase in generation and emissions from existing fossil-fuel
30790 power plants.

30791 **Table 3-211. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple**
30792 **Objective Alternative 4, 2022**

Geographic Scope	Emissions Metric	No Action Alternative (NAA)	MO4 (Conventional Least-Cost Replacement)	MO4 (Zero-Carbon Replacement)
Pacific Northwest	Regional Annual Emissions (MMT CO ₂)	36.7	39.8	37.0
	Difference from NAA (MMT CO ₂)	–	3.1	0.31
	Difference from NAA (%)	–	8.4	0.8
Western Interconnection	Regional Annual Emissions (MMT CO ₂)	163	167	163
	Difference from NAA (MMT CO ₂)	–	4.4	0.83
	Difference from NAA (%)	–	2.7	0.5

30793 Notes: Pacific Northwest estimates include Jim Bridger and half of the remaining North Valmy coal power plant
30794 emissions. See footnote 16 for further description of these power plants. The conventional least-cost resource
30795 replacement portfolio relies primarily on natural gas generation to replace the reduction in hydropower, whereas
30796 the zero-carbon resource replacement portfolio relies primarily on generation from renewable resources.
30797 Source: AURORA outputs

30798 **Table 3-212. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple**
30799 **Objective Alternative 4 (2022 to 2041)**

Alternative (Resource Replacement Portfolio)	Emissions (MMT CO ₂)				
	2022	2027	2032	2037	2041
No Action Alternative - Total Emissions in the Pacific Northwest	36.7	36.6	36.5	36.5	36.5
MO4 (Conventional Least-Cost) Increase Relative to No Action Alternative	3.1 (8.4%)	3.5 (9.5%)	3.6 (9.7%)	3.6 (9.9%)	3.6 (9.9%)
MO4 (Zero-Carbon) Increase Relative to No Action Alternative	0.3 (0.83%)	0.4 (1.1%)	0.4 (1.0%)	0.3 (0.9%)	0.3 (0.9%)

30800 As described in Section 3.8.3.2, the power analysis is sensitive to alternative assumptions
30801 regarding coal capacity in the region. Under a limited or no coal portfolio, the emissions effects
30802 under MO4 would depend on the nature of replacement resources (fossil fuel and renewable
30803 resources). If the reduction in coal were replaced by zero-carbon resources, emissions could
30804 decrease substantially; however, the amount of zero-carbon resources would be very large, and
30805 even more substantial with the additional effect of the reduction in hydropower under MO4, as
30806 presented in Table 3-213.

30807 Across the wider Western Interconnection, excluding regions outside of the United States,
30808 average emissions from power generation under MO4 assuming the conventional least-cost
30809 replacement portfolio would be 167 MMT CO₂ in 2022, 2.7 percent greater than No Action
30810 Alternative. Assuming the zero-carbon portfolio, average emissions would be 163 MMT CO₂, or
30811 half a percent greater than No Action Alternative in 2022. The more modest effect on emissions
30812 from power generation across the broader Western Interconnection indicates that the effect of
30813 MO4 on GHG emissions is concentrated in the Pacific Northwest.

30814 **Greenhouse Gas Emissions from Navigation and Transportation under Multiple Objective**
30815 **Alternative 4**

30816 MO4 would slightly increase costs for deep-draft navigation traffic below Portland, Oregon, and
30817 slightly decrease costs for shallow-draft traffic from Portland to McNary Dam, as well as on the
30818 Snake River. As described in Section 3.10.3, the increased costs for deep-draft traffic may result
30819 in “light loading” vessels, requiring more trips to transport the same amount of freight, and a
30820 small increase in the number of tug operations. Conversely, shallow-draft traffic would
30821 experience very slight reduction in costs (0.1 percent) in comparison to No Action Alternative.

30822 The slight increase in shipping activity (i.e., barge trips) may result in a slight increase in GHG
30823 emissions under MO4 relative to No Action Alternative in the long term. This effect would likely
30824 be limited, and negligible as compared with the GHG emissions effects from power generation
30825 under the alternative.

30826 **Greenhouse Gas Emissions from Construction Activities under Multiple Objective Alternative 4**

30827 Construction operations under MO4 include turbine upgrades, spillway improvements, and
30828 many additions for fish passage at multiple CRS projects. These structural measures require
30829 construction equipment and vehicles that emit GHG when burning fuel. In addition,
30830 construction of replacement resources to offset the reduction in hydropower generation under
30831 MO4 would result in short-term GHG emissions effects. These effects would be short term,
30832 occurring during the construction period, and very modest as compared with the power
30833 generation-related GHG emissions under MO4.

30834 **Other Greenhouse Gas Emissions Sources under Multiple Objective Alternative 4**

30835 MO4 would not affect reservoir methane emissions. Additionally, MO4 would not result in
30836 changes in land use (e.g., conversion from inundated to vegetated landscapes) that would
30837 affect carbon sequestration potential of the landscape.

30838 **Meeting Emissions Reductions Targets under Multiple Objective Alternative 4**

30839 Under MO4, assuming the zero-carbon resource replacement portfolio, the increased GHG
30840 emissions in resources located in Oregon and Washington would be minimal, with none
30841 exceeding 0.1 MMT CO₂. However, this would require more zero-carbon resource acquisitions
30842 for MO4 than for the No Action Alternative to achieve the states' goals. The largest increases
30843 occur in Montana due to the coal generation, which would be able to be sold in some areas
30844 (other than Washington and Oregon).

30845 **Social Cost of Carbon Effects under Multiple Objective Alternative 4**

30846 MO4 results in an increase in GHG emissions relative to No Action Alternative. This analysis
30847 evaluates implications on emissions according to both the conventional least-cost and zero-
30848 carbon replacement portfolios. As previously described, recent and emerging policy focused on
30849 reducing energy-sector GHG emissions indicates that the zero-carbon resource replacement
30850 portfolio may better reflect future trends. Appendix G includes the calculation of the emissions
30851 and SCC values by year over the timeframe of the analysis.

30852 The central estimate for the present value of the increased climate-related damages under
30853 MO4 is \$310 million (assuming a 3 percent discount rate in accordance with best practices)
30854 (IWG 2016) and assuming the additional zero-carbon generation is constructed to replace lost
30855 hydropower generation. This equates to an annualized cost of \$20 million. These costs reflect
30856 the global increase in climate-related damages associated with the expected marginal increase
30857 in GHG emissions under MO4. These values reflect a 1.0 percent increase in GHG emissions
30858 relative to the No Action Alternative over the 20-year timeframe.

30859 Table 3-213 presents a range of results reflecting alternative assumptions regarding the
30860 appropriate discount rate for discounting these types of intergenerational effects, as well as a
30861 portfolio that reflects greater than expected (95th percentile) damages from climate change over
30862 time. Due to the considerable uncertainty inherent in the calculation of the SCC values, the results
30863 of the analysis according to these alternative assumptions are presented for consideration.

30864 **Table 3-213. Present Value and Annualized Values of Changes in CO₂ Emissions in the Pacific**
 30865 **Northwest under Multiple Objective 4 Relative to No Action Alternative (2022 to 2041, 2019**
 30866 **U.S. Dollars)**

Alternative (Resource Replacement Portfolio)		Total Discounted SCC			
		Present Value 5% Average	Present Value 3% Average	Present Value 2.5% Average	Present Value 3% 95 th
MO4 (Conventional Least-Cost)	Total	\$760 million	\$3,000 million	\$4,600 million	\$9,100 million
	Annualized	\$58 million	\$200 million	\$290 million	\$600 million
MO4 (Zero-Carbon)	Total	\$78 million	\$310 million	\$470 million	\$930 million
	Annualized	\$6.0 million	\$20 million	\$30 million	\$61 million

30867 Notes: These estimates reflect three different discount rates (the averages used by three different climate models)
 30868 and a high estimate of the 95th percentile for potential lower-probability, high-impact outcomes to capture
 30869 uncertainty. The central estimate is the 3 percent discount rate. All values in this table rounded to two significant
 30870 digits. Full values for each portfolio as well as the schedule for each discount rate SCC estimates are in Appendix G.
 30871 Annualized values are calculated by first estimating the total present value of the future stream of costs, and then
 30872 calculating the annualized estimates (i.e., average annual equivalent) employing the same discount rate assumption.
 30873 Source: IWG (2016): for SCC cost schedule over time, see Appendix G for full schedule

30874 **SUMMARY OF EFFECTS**

30875 Overall, long-term adverse effects would be related to reductions in hydropower generation,
 30876 which would increase fossil fuel generation and associated emissions. Increased coal generation
 30877 under MO4 in Wyoming and Montana would increase emissions of SO₂, NO_x, and PM. The coal
 30878 plants are near existing nonattainment areas for PM, and the additional emissions from coal
 30879 have the potential to exceed *de minimis* levels of PM emissions, potentially affecting
 30880 compliance with NAAQS.

30881 In Regions C and D, long-term adverse effects would also be associated with increased barge
 30882 transport along the lower Snake River due to reduced efficiency of shipping (i.e., light loading
 30883 the barges to avoid grounding). The increased emissions would likely be low intensity, however,
 30884 and very minor relative to the power generation-related emissions. Short-term adverse effects
 30885 are due to construction activities, including structural measures and construction of
 30886 replacement power resources, which would generate emissions. These would likely be short
 30887 term (during the period of construction) and localized to the project sites in Regions C and D.

30888 In Region A, reduced reservoir elevation levels at Hungry Horse Dam may occur for ten months
 30889 of the year. The exposed sediment may increase fugitive windblown dust and associated PM
 30890 emissions. This effect is localized and may be mitigated by planting vegetation or restrictions on
 30891 activities on the sediment such as recreation and use of vehicles. The emissions would be
 30892 located adjacent to nonattainment areas for PM in Columbia Falls and Whitefish, Montana.
 30893 Given the seasonal variation in water levels and potential for mitigation to avoid adverse
 30894 effects, the likelihood that fugitive dust emissions would affect the current nonattainment
 30895 areas is low.

30896 Overall, the effects of MO4 on air quality would most likely be moderate and adverse over the
30897 long term, primarily outside of the Pacific Northwest in areas of Montana and Wyoming, and
30898 minor and adverse in the short term in Regions A, C, and D.

30899 Over the 20-year timeframe, the analysis identifies increased power generation from fossil fuels
30900 relative to No Action Alternative, primarily from coal, even under the zero-carbon resource
30901 replacement portfolio. Long-term adverse effects are also associated with increased barge
30902 transport along the lower Snake River in Regions C and D due to reduced efficiency of shipping.
30903 The increased emissions would be very modest relative to the power generation-related
30904 emissions. MO4 would also result in short-term adverse effects on GHG emissions from
30905 construction activities, including structural measures and construction of replacement power
30906 resources. Overall, effects of MO4 on GHG emissions would be moderate and adverse over the
30907 short and long term for similar reasons to MO3.

30908 **3.8.4 Tribal Interests**

30909 There are numerous tribal lands within the study area where air quality is potentially affected
30910 by operations. Because of the nature of airsheds, the power grid, and where additional power
30911 plants may be constructed, air quality near tribal lands would be affected, either beneficially or
30912 negatively, across the entire study area. Construction-related emissions, such as building
30913 additional powerhouse surface passages, improved turbines, or lamprey passage structures,
30914 would have short-term, localized effects to nearby communities. Depending on the alternative,
30915 there would be adverse effects to air quality in Regions A, C, and D, and also in Montana and
30916 Wyoming due to construction, changes in hydropower generation, and increased coal and
30917 natural gas power generation.

30918 MO2 would have the least negative effects to air quality near tribal lands because there would
30919 be more hydropower generation than under the No Action Alternative, barging would continue
30920 on the lower Snake River the same as the No Action Alternative, and there would be no
30921 construction related to replacement power resources as there are under MO1, MO3, and MO4.
30922 The exception for MO2 is at Dworshak where there would be minor effects from potential
30923 increased fugitive dust emissions due to reduced reservoir water levels. This would most likely
30924 impact the Nez Perce Tribe as it overlaps spatially with the Nez Perce Reservation.

30925 MO3 would result in adverse effects to air quality near tribal lands due to dam breaching and
30926 the potential for increased reliance on coal or natural gas. This would be less if the output of
30927 the Snake River dams was replaced with renewable energy. There would also be more
30928 construction-related effects that would have short-term, adverse effects to tribes near the
30929 Lower Snake River dams, such as the Umatilla Tribe and Nez Perce Tribe. Increased greenhouse
30930 gas emissions from moving goods that would have been barged would impact air quality near
30931 tribal lands along the Columbia River.

30932 MO4 would have similar, albeit lower, effects compared to MO3 due to the changes in spill that
30933 affect hydropower generation and navigation.

30934 **3.9 FLOOD RISK MANAGEMENT**

30935 Flood Risk Management (FRM) is the process of identifying, evaluating, selecting, implementing,
30936 and monitoring actions intended to reduce the risk associated with flooding. The FRM analysis
30937 describes estimated effects of the MOs on FRM in the CRSO study area (defined in Section 3.9.2,
30938 *Area of Analysis*). Specifically, the MOs may affect the reservoir operations and/or system
30939 configuration (breaching of lower Snake River projects). The purpose of the CRSO FRM analysis is
30940 to assess whether changes in reservoir operations and system configuration would change flood
30941 risk when compared to the No Action Alternatives. Therefore, the focus of this analysis is to assess
30942 flood risk management, and to identify the communities, property, and resources downstream of
30943 reservoirs and in reservoir pools that could face increased frequency or magnitude of flooding
30944 under any of the identified MOs. To accomplish this, the FRM analysis examines potential changes
30945 in river flow and stage conditions in various locations throughout the system. River flow and stage
30946 information is compared to thresholds for flood hazards, as established by the National Weather
30947 Service (NWS) to understand flood risk conditions under the No Action Alternative, as well as
30948 how the conditions associated with the potential for flood hazards could change under the MOs.

30949 **3.9.1 Introduction and Background**

30950 Throughout history, numerous floods have occurred throughout the Columbia River Basin with
30951 consequences that have ranged from nuisance flooding, to catastrophic. Since the enactment of
30952 the Flood Control Act of 1917, the Corps has played a significant Federal role in managing flood
30953 risk nationwide. The mission of the Corps and how that mission has been implemented has
30954 evolved over time; moving from flood control to FRM. The transition to the current terminology
30955 reflects the natural variability in flood risk, the uncertainty of performance of infrastructure like
30956 levees and dams, and the uncertainty of which resources are vulnerable to flooding. Over the last
30957 100 years, many FRM projects have been implemented in the Columbia River Basin, including
30958 several Federal projects. Although flood risk has decreased with these projects in place, no
30959 project can eliminate risk; residual risks remain even after projects have been implemented.

30960 The role of the Federal government in managing flood risk in the Columbia River Basin began in
30961 1925, when Congress requested that the Corps provide a cost estimate for preparing a detailed
30962 survey of the nation's navigable rivers for the development of navigation, hydropower,
30963 irrigation, and flood control. The Corps produced a comprehensive proposal that included the
30964 Columbia River Basin. That proposal was later adopted in U.S. Congress House Document (H.
30965 Doc.) 69-308 (1926)¹ and additional studies were authorized. The series of subsequent reports
30966 is known as the House Document 308 reports and present the preliminary concepts for the
30967 development of the Columbia River Basin.²

30968 During the 1930s, a series of disastrous nationwide floods and the financial depression led to
30969 the passage of the Flood Control Act of 1936. The 1936 Act established a nationwide policy for

1 House Document 308, 69th Congress, 1st Session (1926).

2 H. Doc. 73-103 (1932) – limited to the mainstem Columbia River; H. Doc. 73-190 (1933) – addressed the Snake River; and H. Doc. 75-704 (1938) – updated the plans for locks and dams on the lower Columbia and lower Snake Rivers

30970 flood control provided by the Federal government in cooperation with local entities, and
30971 provided funding specifically for flood control projects.³ Many of the existing levees in the
30972 Columbia River Basin were constructed under this act.

30973 Shortly afterwards in 1948, a major flood devastated communities along the Columbia River, in
30974 particular Vanport, Oregon, which was located adjacent to Portland, Oregon. Vanport was a
30975 “new town” created on the banks of the Columbia River primarily to build ships during World
30976 War II. Following the 1948 flood, political pressure and a directive from President Truman
30977 accelerated the completion of the Corps studies previously initiated by H. Doc. 308. The results
30978 of the studies were summarized in H. Doc. 81-531: “Columbia River and Tributaries,
30979 Northwestern United States,” in March 1950. The report introduced a systemwide approach to
30980 FRM (generally referred to as flood control in this and earlier documents) and included a main
30981 control plan that proposed numerous new reservoirs and levee projects.

30982 H. Doc. 531 served as the basis for the design of the present system. Over the next decade,
30983 however, the proposed control plan evolved, as many of the proposed projects were further
30984 evaluated and alternative projects were considered due to engineering, economic, political and
30985 public opinion concerns. Also in the 1960s, the United States and Canada began negotiations
30986 for implementing the Columbia River Treaty (CRT). The history of the system control plan can
30987 be tracked through the details of several CRT-specific studies and reports including the Special
30988 InterAgency Study: “U.S. and Canadian Storage Projects, Columbia River and Tributaries” (U.S.
30989 Department of the Interior 1955) and Report of the International Joint Commission, United
30990 States and Canada, Principles for Determining and Apportioning Benefits from Cooperative Use
30991 of Storage Waters and Electrical Inter-Connection within the Columbia River System
30992 (International Joint Commission 1959).

30993 The CRT was signed in 1961 and later ratified on September 16, 1964. The CRT required Canada
30994 to provide 15.5 Maf of storage at three dam sites: Duncan, Arrow (later renamed Hugh
30995 Keenleyside), and Mica. Canada constructed 20.5 Maf of storage, including an extra 5 Maf of
30996 non-CRT storage at Mica Dam. The CRT provided 8.45 Maf of primary flood control space and
30997 the remaining space in Canada as secondary flood control space. The CRT also allowed the
30998 United States the option to build Libby Dam, which created a reservoir that extended across the
30999 U.S.-Canada border into Canada.

31000 The FRM projects developed and implemented in the last century play an important role in the
31001 communities of the Columbia River Basin by reducing risk to lives, property, and the
31002 environment. Flood risk is also managed by systems of levees, floodwalls, and bank protection
31003 developed locally (either without Federal participation or constructed by the Corps in some
31004 cases with a cost-share local sponsor). In addition, many areas have adopted measures such as
31005 floodplain regulations, land use regulation, and improved land treatment practices, all of which
31006 are measures that manage flood risk.

³ The 1936 act authorized construction of approximately 250 projects.

31007 **3.9.2 Area of Analysis**

31008 There are 14 CRS projects located within the U.S. portion of the Columbia River Basin, six of
31009 which are storage projects. A storage project is capable of drawing down its pool and refilling to
31010 store large amounts of water seasonally to regulate flows downstream for a variety of
31011 purposes, including FRM. The six CRS storage projects are described in Table 3-214. The table
31012 presents the volume of active storage (the portion of a reservoir that can be used for FRM
31013 and/or other purposes) and authorized system storage for FRM purposes.

31014 **Table 3-214. Columbia River System Storage Projects**

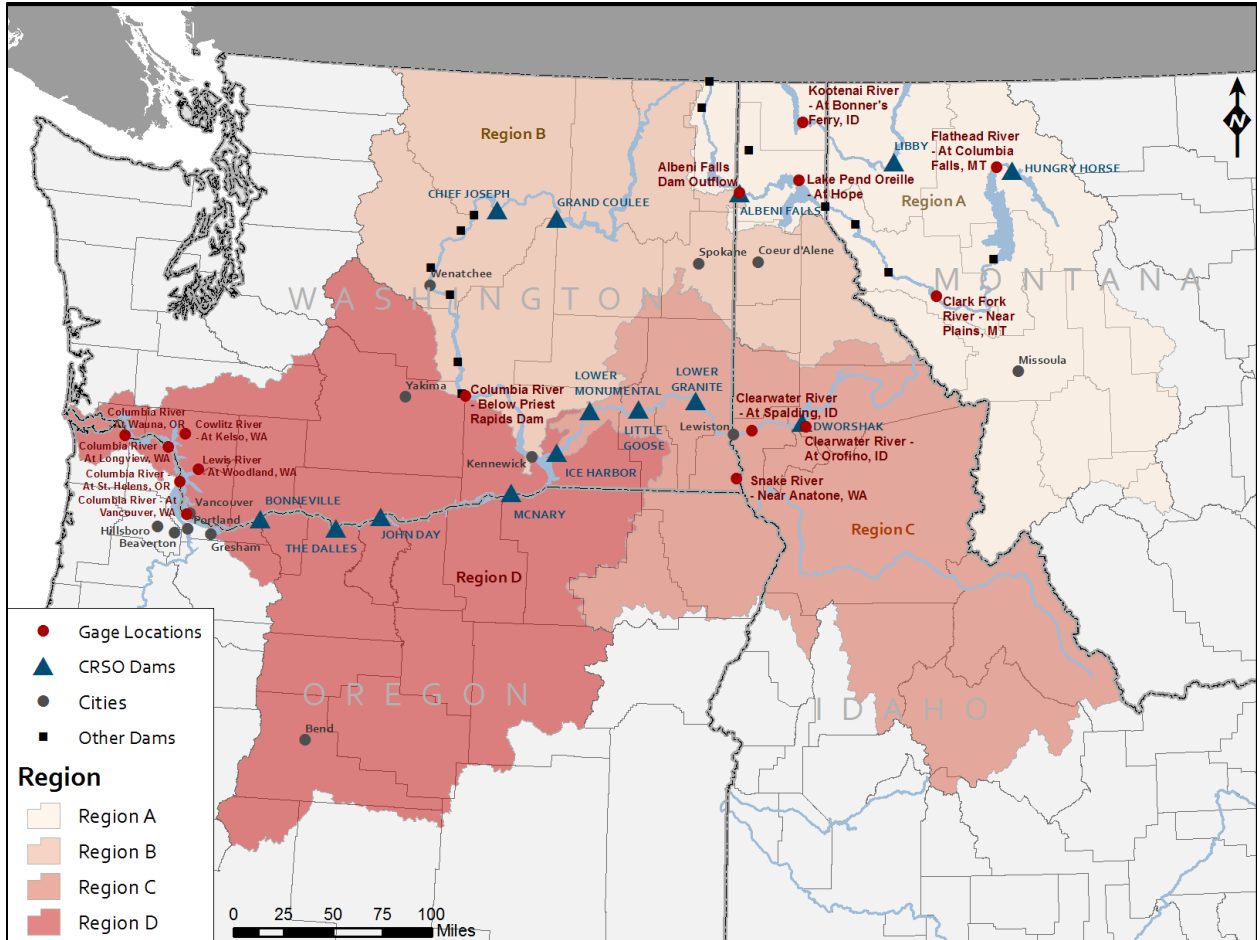
CRSO Region	Project	River	Owner	Active Storage (Maf) ¹	Authorized System Storage for FRM (Maf) ²
A	Libby	Kootenai	Corps	4.980	4.980
A	Hungry Horse	South Fork Flathead	Reclamation	2.980	2.980
A	Albeni Falls	Pend Oreille	Corps	1.155	0.600
B	Grand Coulee	Columbia	Reclamation	5.349	5.349
C	Dworshak	North Fork Clearwater	Corps	2.016	2.016
D	John Day	Columbia	Corps	0.530	0.530
Total				16.847	16.292

31015 1/ Active storage is the portion of a reservoir that can be used for flood control and other purposes.

31016 2/ Authorized System Storage for FRM is the storage volume specifically allocated for FRM.

31017 The geographic scope of the FRM study area includes the CRS and all urban and rural areas and
31018 populations potentially affected by change to flood risk. The areas where an alternative could
31019 potentially affect flood risk are either downstream of one of the six storage projects, or
31020 upstream within the reservoir of the project. The study team delineated the study area into
31021 separate hydraulically distinct reaches to facilitate the analysis of flood risk. The details of this
31022 analysis are described in detail in Section 3.2, *Hydrology and Hydraulics*.

31023 Flood gages have been installed in areas near population centers and where flood risk is a
31024 concern. This analysis evaluates a subset of the flood gages to characterize current flows and
31025 anticipated changes in flood risk under the MOs. Figure 3-192 provides an overview of the
31026 study regions, relevant projects, and gages that are the focus of the analysis.



31027
31028 **Figure 3-192. Columbia River System Dams, Leveed Areas, and Important Gages for Flood Risk**
31029 **Management**

31030 Note: The gages on the above map as well as historical stage/flow and flood hazard category threshold data used
31031 in this assessment are taken from The NWS Advanced Hydrologic Prediction Service at
31032 <https://water.weather.gov/ahps/>.

31033 **3.9.3 Affected Environment**

31034 The sections that follow describe flood risk by CRSO region, including the history of flooding
31035 within each region, and the location of levees that provide FRM to the identified communities.

31036 Flood risk is an estimate of the risk of an area to flooding. Flood risk is a function of the
31037 hydrologic and hydraulic flood hazards that exist in a particular area (river flows and stages),
31038 the expected performance of levees and other infrastructure to reduce the probability of
31039 flooding, and finally, the consequences if flooding does reach communities or property (i.e., the
31040 harm that may be caused).

31041 As a tool for measuring potential change to FRM conditions, flood hazard categories developed
31042 by the NWS are utilized for assessing flood hazards measured by the potential for inundation
31043 that involves risks to life, health, property, and natural floodplain resources and functions

31044 (FEMA 2019). The NWS uses the following flood hazard categories, ranked by river stage (gage
31045 height):

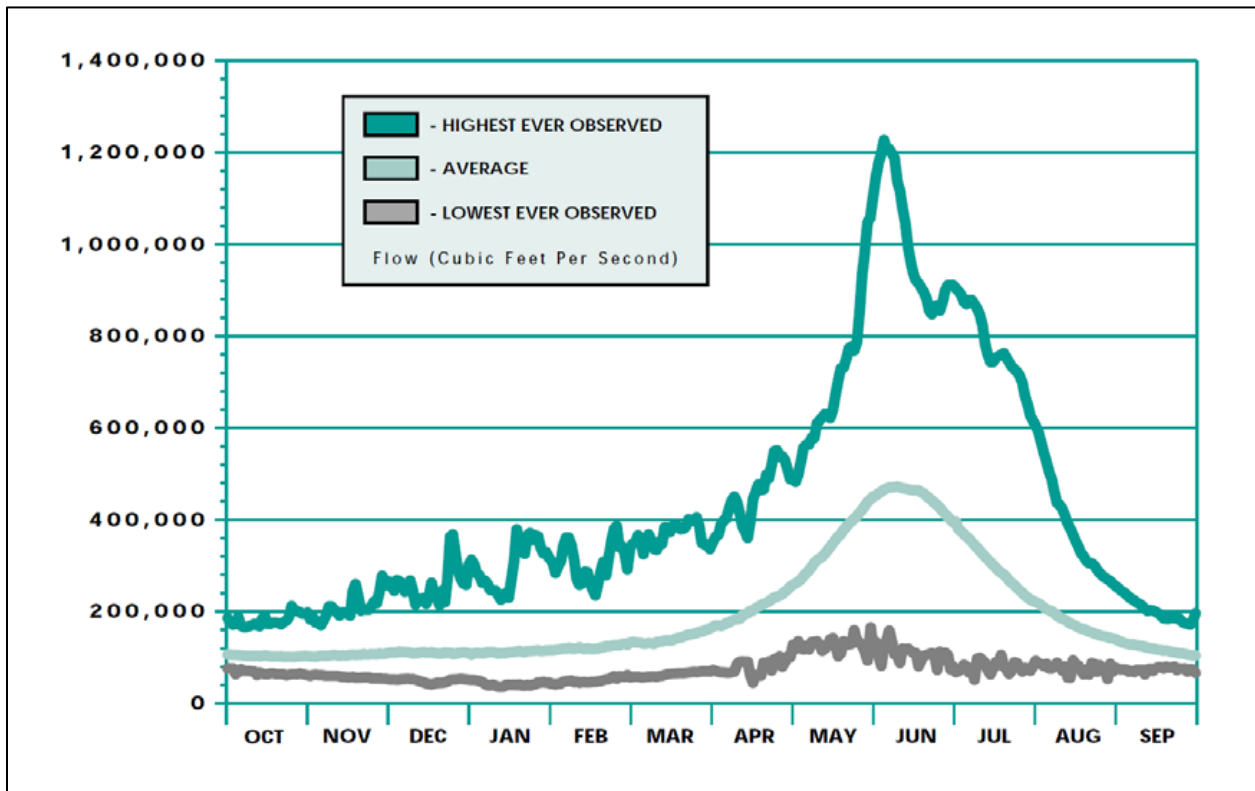
- 31046 • **Action Stage:** the stage which, when reached by a rising stream, represents the level where
31047 the NWS or a partner/user needs to take some type of mitigation action in preparation for
31048 possible significant hydrologic activity.
- 31049 • **Flood Stage:** the stage above which a rise in water surface level begins to create a hazard to
31050 lives, property, or commerce. The issuance of flood advisories or warnings is linked to flood
31051 stage.
- 31052 • **Moderate Flood Stage:** the stage above which a rise in water surface level begins to have
31053 some inundation of structures and roads near the stream. Some evacuations of people
31054 and/or transfer of property to higher elevations may be necessary. A Flood Warning should
31055 be issued if moderate flooding is expected during the event.
- 31056 • **Major Flood Stage:** the stage above which a rise in water surface level begins to have
31057 extensive inundation of structures and roads. Significant evacuations of people and/or
31058 transfer of property to higher elevations are necessary. A Flood Warning should be issued if
31059 major flooding is expected during the event.

31060 The potential for flood hazards in the Columbia River Basin is typified by two important runoff
31061 patterns in the Columbia River Basin: the snowmelt runoff in the interior east of the Cascade
31062 Mountain Range, and the rainfall runoff from the coastal drainages west of the Cascades
31063 affecting the lower Columbia. Most of the annual precipitation in the Columbia River Basin
31064 occurs in the winter, with the largest share in the mountains falling as snow. The moisture that
31065 is stored during the winter in the snowpack is released in the spring and early summer. Stream
31066 flow typically begins to rise in mid-April, reaching a peak flow during May or early June. About
31067 60 percent of the natural annual runoff in the Basin occurs during May, June, and July.

31068 Flood risks are managed in the Columbia River Basin by a system of FRM storage reservoirs,
31069 which in total provide approximately 40 Maf of storage capacity. This is compared to an
31070 average annual runoff volume of 130 Maf in the basin, and a historic maximum runoff of 192
31071 Maf. The ability of the system of reservoirs to manage flood risk is further limited by the ability
31072 to predict, or forecast, the volume of runoff through the year.

31073 The Pacific Northwest has two principal flood seasons. November through March is the rain-
31074 produced flood period. These floods occur most frequently on streams west of the Cascade
31075 Range. May through July is the snowmelt flood period. Most of the annual precipitation in the
31076 Columbia River Basin occurs in the winter, with the largest share in the mountains falling as
31077 snow. The moisture that is stored during the winter in the snowpack is released in the spring
31078 and early summer. East of the Cascade Range, snowmelt floods dominate the runoff pattern for
31079 the Columbia River Basin. The most serious snowmelt floods develop when extended periods of
31080 warmer weather combine with a large accumulation of winter snow. The worst floods result
31081 when heavy rains fall during a heavy snowmelt.

31082 The Columbia River has an average annual flow volume at its mouth of about 198 Maf and an
31083 average annual flow of 273,500 cfs. A location in the lower Columbia River Basin, at The Dalles,
31084 Oregon, is where system runoff flows are modeled and measured. At this location, the average
31085 annual flow volume is 134 Maf and the average annual flow is 185,000 cfs. Average, high, and
31086 low Columbia River unregulated stream flows from historical records at The Dalles are shown in
31087 Figure 3-193. Historic records show an annually recurring pattern, with peak flows in late
31088 spring.



31089
31090 **Figure 3-193. Columbia River Streamflows as Measured at The Dalles, Oregon**

31091 Seasonal flooding resulting from these snowmelt events was the primary driver for
31092 development of the FRM system on the Columbia River.

31093 U.S. and Canadian water management agencies use seasonal runoff volume forecast
31094 information to formally plan the storage and release of water from the reservoirs. Corps, British
31095 Columbia Hydro, Reclamation, Natural Resource Conservation Service (NRCS) and the
31096 Northwest River Forecast Center produce seasonal runoff volume forecasts (rain and snowmelt)
31097 for numerous locations in the Basin, all of which are considered when determining the amount
31098 of space needed in the flood storage reservoirs. However, full knowledge of where and when
31099 flooding would occur still remains uncertain because it is not possible to accurately forecast the
31100 weather more than a few days ahead. The amount of rain and variations in temperature over
31101 just a few days, for example, can strongly influence the timing and extent of runoff.
31102 Unpredictable weather, along with climatic influences, can result in dramatic fluctuations in
31103 runoff volumes making FRM in the Columbia River Basin a major challenge.

31104 No single agency or action can manage these floods. An entire system, with both manmade and
31105 natural features, contributes to flood reduction. Huge reservoirs can capture vast quantities of
31106 water, wetlands can absorb floodwaters and even the individual actions of property owners can
31107 help. The Corps, Bonneville, and other agencies also assist communities with non-structural
31108 measures that help manage floods, such as establishing response and land development plans
31109 to reduce flood risks.

31110 FEMA defines special flood hazard areas as areas that will be inundated by a flood event that
31111 has a 1 percent chance of being equaled or exceeded in any given year (also called a 100-year
31112 flood). Areas of moderate flood hazard are identified as areas between the 0.1 percent and 0.2
31113 percent annual chance of exceedance (between the 100-year flood and the 500-year flood
31114 mark) (FEMA 2019a). Communities that intersect the study area as well as populations that fall
31115 within these flood hazard areas are described in the following sections.

31116 **3.9.3.1 Region A**

31117 Region A includes the Libby, Hungry Horse, and Albeni Falls storage projects. The river reaches that are
31118 relevant to the FRM analysis in Region A are shown in Table 3-215 and are consistent with those used in
31119 the H&H resources analysis. Region A includes four gages that were selected for this analysis: Pend
31120 Oreille River Outflow from Below Albeni Falls; Clark Fork near Plains, Montana; Columbia Falls, Montana;
31121 and Bonners Ferry, Idaho. These gages are located on the Flathead River downstream of Hungry Horse
31122 Dam, and on the Kootenai River downstream of Libby Dam. Figure 3-194 presents the stream reaches,
31123 gages for which flood hazard categories have been defined by NWS, and large population centers that
31124 are relevant to FRM in Region A.

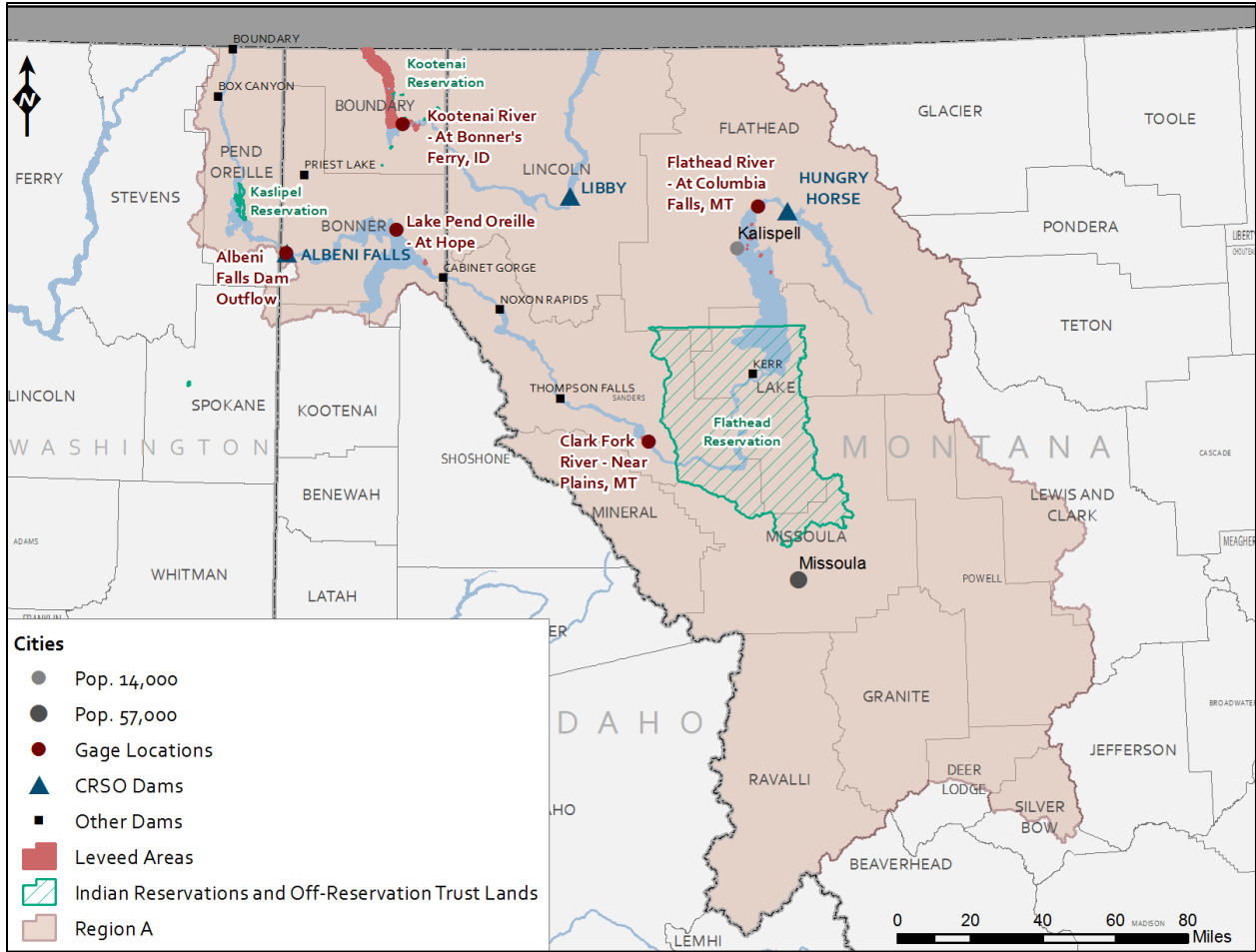
31125 Most areas experienced flooding in the first half of the twentieth century, but flood frequency
31126 has been reduced in more recent years due to FRM efforts, including installation of levees in
31127 some areas. The most recent flood incident in this region was in Clark Fork, Idaho, which
31128 experienced flooding in 2018, although a non-Federal levee exists in that reach. The river
31129 communities that fall within Region A and the history of flooding in those communities is briefly
31130 summarized as follows:

- 31131 • The Pend Oreille River in Reach 22 (R22) and R23 has historically flooded
31132 near Cusick and the Kalispel Reservation, near Newport Washington, and rural areas
31133 downstream to Metaline Falls. There was extensive damage in the 1948 flood. Flooding also
31134 occurred in 1933 and 1894. Flooding has not occurred recently in this area. R23 includes the
31135 Pend Oreille River Outflow from Below Albeni Falls gage.
- 31136 • Flooding in R24 has historically occurred near Old Town and Priest River, Idaho on the Pend
31137 Oreille River, around areas of Lake Pend Oreille including Sandpoint, Idaho and low-lying
31138 regions of the lake, and on the Clark Fork River at Clark Fork Idaho. Floods have occurred in
31139 R24 in 1894, 1913, 1927, 1928, 1933, 1948, 1956, 1969, and 1974. The community of Clark
31140 Fork, Idaho experienced flooding in 2018. The Lightning Creek Levee is a non-Federal levee
31141 in R24 that provides FRM for the town of Clark Fork, Idaho.

- 31142 • Flooding along the Clark-Fork and Flathead Rivers in R25, R26, and R27 has occurred in the
31143 past at Plains, Montana and in rural areas near Noxon, Paradise and Dixon, Montana.
31144 Approximately half of R27 is within the Flathead Reservation on the Flathead River. Major
31145 flooding in these areas occurred in 1894 and 1948. There are two non-Federal levees on the
31146 left bank of the Clark Fork River opposite Plains, Montana. R27 includes the Clark Fork near
31147 Plains, Montana, study gage.
- 31148 • R28 has experienced flooding historically along the Flathead River at Columbia Falls
31149 downstream to Flathead Lake, and in areas around the lake. Part of R28 is within the
31150 Flathead Reservation in the lower portions of Flathead Lake. The flood of record in 1964
31151 caused catastrophic flooding in the region. There are eight non-Federal levees systems in
31152 R28 along the Flathead River, providing FRM to portions of Evergreen, Bigfork and Kalispell,
31153 Montana and the surrounding communities. The stretch of R28 shown in the map below
31154 contains approximately 0.5 square miles of leveed areas, related to 3 non-Federal levees.
31155 R28 includes the Columbia Falls, Montana, study gage.
- 31156 • The Kootenai River in R29 and R30 was subject to frequent and major flooding prior to the
31157 construction of Libby Dam, whose operation commenced in 1972. Historically, flooding
31158 occurred in the Kootenai Flats area, which encompasses all of R29, extending from Bonners
31159 Ferry, Idaho, to Kootenay Lake in Canada. Large areas of agricultural land, as well as the
31160 community of Bonners Ferry are subject to potential flooding. Much of the land is protected
31161 by non-Federal levees and dikes. R29 and R30 encompass lands belonging to the Kootenai
31162 Tribe of Idaho. During the 1948, flood all levees in R29 either failed or were overtopped,
31163 and about 44,000 acres of farm land were inundated in the Kootenai Flats area, 30,000
31164 acres being in the United States.⁴ Levees in R29 provide FRM to the City of Bonners Ferry,
31165 Idaho, and the Kootenai Flats agricultural region downstream. R29 includes the Bonners
31166 Ferry, Idaho, study gage.
- 31167 The estimated population of communities in Region A is approximately 78,000, of which 10,000
31168 reside in the flood hazard area.⁵ Region A rural areas include an estimated population of
31169 approximately 35,000 people, of which 6,000 are located in the flood hazard area. Communities
31170 that intersect the study area as well as populations that fall within the flood hazard areas in
31171 Region A are listed in Table 3-216. The largest population in the study area is near Kalispell and
31172 Evergreen, Montana.
31173 reservation trust lands in Region A, including the Kootenai Tribe of Idaho, the Confederated
31174 Salish and Kootenai Tribes, and the Kalispel Tribe of Indians.

⁴ House Document 531, 81st Congress, 2nd Session (1950).

⁵ Populations within the 1% annual chance exceedance (100-year) and 0.2% annual chance exceedance (500-year) flood zones were estimated with GIS software using U.S. Census block data in conjunction with FEMA flood insurance rate map (FIRM) data. Populations located outside of community boundaries but within the hydrologic and hydraulic modeling area are considered as rural.



31175
31176 **Figure 3-194. Locations of Columbia River System Dams, Levees, and Other Dams in Region A**

31177 **Table 3-215. River Reaches in Region A**

Reach	Description
R22	Pend-Oreille River – Canada Border to Box Canyon Dam (Pend Oreille RM 16–33)
R23	Pend-Oreille River – Box Canyon Dam to Albeni Falls Dam (Pend Oreille RM 33–89)
R24	Pend-Oreille River – Albeni Falls Dam to Cabinet Gorge Dam (Pend Oreille RM 90–157)
R25	Clark Fork River – Cabinet Gorge Dam to Noxon Rapids Dam (Clark Fork RM 15–34)
R26	Clark Fork River – Noxon Rapids Dam to Thompson Falls Dam (Clark Fork RM 35–72)
R27	Clark Fork + Flathead Rivers – Thompson Falls Dam to Seli’š Ksanka Qlispe’ (formerly Kerr) Dam (Clark Fork RM 72–110; Flathead RM 1–74)
R28	Flathead and Whitefish Rivers – Seli’š Ksanka Qlispe’ Dam to Hungry Horse Dam (Flathead RM 74–159, includes Whitefish Rivers)
R29	Kootenai River – Canadian Border to Moyie Springs, ID (Kootenai RM 103–157)
R30	Kootenai River – Moyie Springs, ID to Libby Dam (Kootenai RM 157–219)

31178

Table 3-216. Population Within Region A 100- and 500-Year Floodplains

Community	2017 Estimated Population ^{1/}	Estimated Population Within Flood Hazard Area ^{3/}	Reach	River – River Mile
Plains, MT	1,093	152	R27	Clark Fork – 101.6
Paradise, MT ^{2/}	184	5	R27	Clark Fork – 108
Heron, MT	258	0	R25	Clark Fork – 21.2
Noxon, MT ^{2/}	218	4	R25	Clark Fork – 31.6
Trout Creek, MT ^{2/}	261	0	R26	Clark Fork – 50.3
Belknap, MT ^{2/}	159	0	R26	Clark Fork – 67.1
Clark Fork, ID	561	524	R24	Clark Fork – 7.9
Thompson Falls, MT	1,378	17	R26	Clark Fork – 70
Weeksville, MT ^{2/}	83	19	R27	Clark Fork – 93.1
Helena Flats, MT ^{2/}	1,105	986	R28	East Whitefish – 11.3
Woods Bay, MT ^{2/}	748	37	R28	Flathead River – 102.5
Lakeside, MT ^{2/}	2,808	72	R28	Flathead River – 106.3
Bigfork, MT ^{2/}	4,957	294	R28	Flathead River – 114.2
Somers, MT ^{2/}	1,204	38	R28	Flathead River – 124.1
Forest Hill Village, MT ^{2/}	225	27	R28	Flathead River – 126.1
Columbia Falls, MT	5,355	0	R28	Flathead River – 149.4
Hungry Horse, MT ^{2/}	866	815	R28	Flathead River – 155.5
Dixon, MT ^{2/}	216	0	R27	Flathead River – 25.8
Old Agency, MT ^{2/}	98	0	R27	Flathead River – 26.6
Bonnars Ferry, ID	2,603	383	R29	Kootenai – 151.9
Moyie Springs, ID	822	0	R29	Kootenai – 158.4
Troy, MT	904	8	R30	Kootenai – 184.7
Libby, MT	2,691	414	R30	Kootenai – 203
Pioneer Junction, MT	959	0	R30	Kootenai – 203
White Haven, MT ^{2/}	577	6	R30	Kootenai – 203
Dover, ID	735	96	R24	Pend Oreille – 115.2
Sandpoint, ID	8,390	185	R24	Pend Oreille – 119.4
Ponderay, ID	1,342	2	R24	Pend Oreille – 120.2
Kootenai, ID	834	0	R24	Pend Oreille – 120.9
Hope, ID	90	0	R24	Pend Oreille – 130.2
East Hope, ID	218	12	R24	Pend Oreille – 130.9
Metaline Falls, WA	245	35	R22	Pend Oreille – 26.9
Metaline, WA	178	0	R22	Pend Oreille – 27.8
lone, WA	459	22	R23	Pend Oreille – 36.9
Cusick, WA	217	12	R23	Pend Oreille – 69.8
Newport, WA	2,140	0	R23	Pend Oreille – 87
Oldtown, ID	194	0	R23	Pend Oreille – 89
Priest River, ID	1,833	19	R24	Pend Oreille – 97.2
Kalispell, MT	23,212	1,054	R28	West Whitefish – 2.8

Community	2017 Estimated Population ^{1/}	Estimated Population Within Flood Hazard Area ^{3/}	Reach	River – River Mile
Evergreen, MT	7,968	5,109	R28	West Whitefish – 5.7
Rural Areas	34,833	5,787	All	
Total	78,388	10,347	All	

31179 ^{1/} Source: U.S. Census Bureau (2017) or latest available data.

31180 ^{2/} Source: ESRI data that is derived from U.S. Census data for unincorporated areas that are census-designated
31181 places.

31182 ^{3/} Includes 1% and 0.2% annual chance exceedance flood hazard areas. Populations within the 1% annual chance
31183 exceedance (100-year) and 0.2% annual chance exceedance (500-year) flood zones were estimated with GIS
31184 software using U.S. Census block data in conjunction with FEMA flood insurance rate map (FIRM) data. Populations
31185 located outside of community boundaries but within the hydrologic and hydraulic modeling area are considered as
31186 rural.

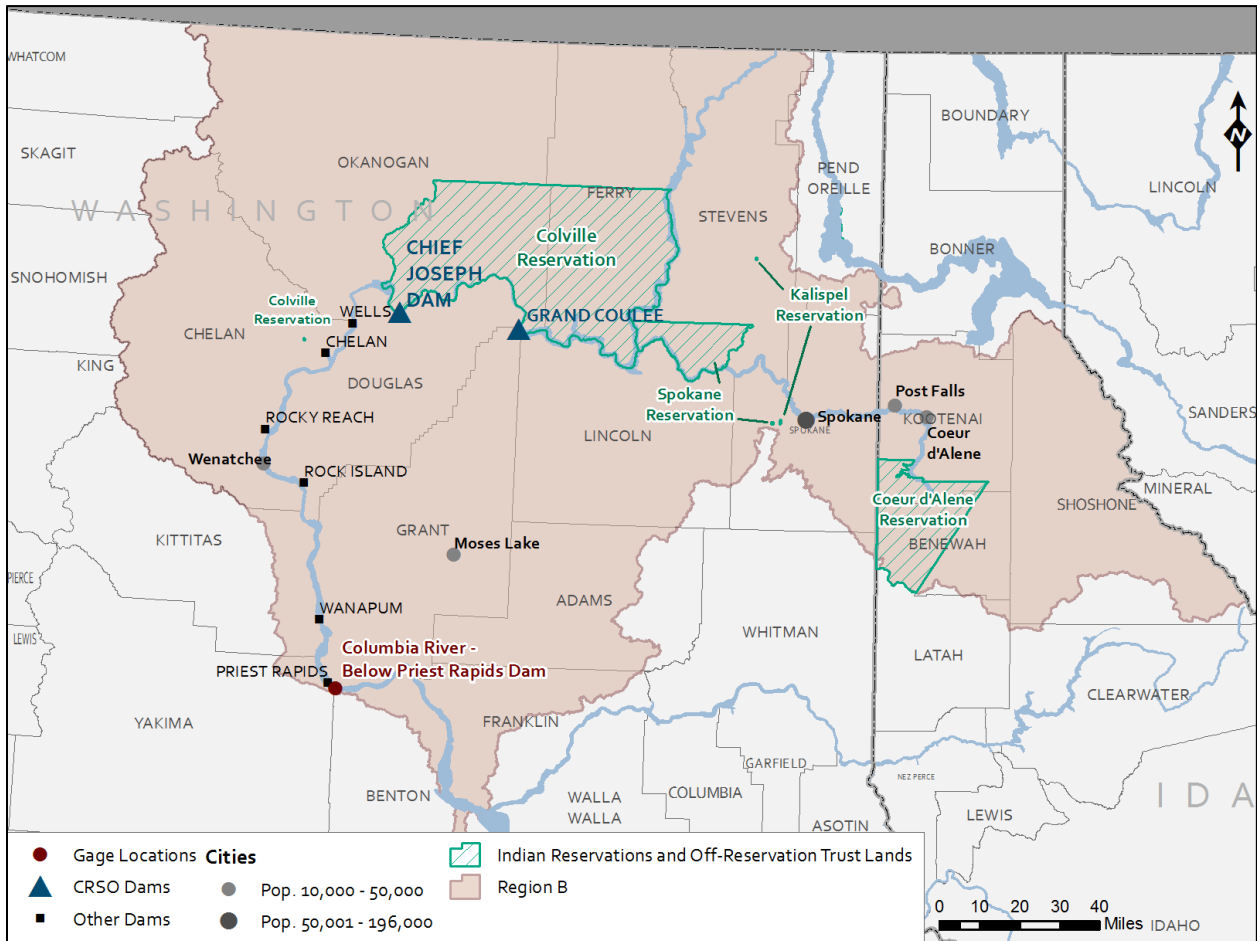
31187 **3.9.3.2 Region B**

31188 Region B includes the Grand Coulee storage project. Another Federal dam, Chief Joseph Dam
31189 near Brewster, Washington, is also in this region, but it is not a storage project. The river
31190 reaches that are relevant to the FRM analysis in Region B are shown in Table 3-217, and are
31191 consistent with those used in the H&H resources analysis. The largest population center in the
31192 affected area is the town of Wenatchee, Washington (population 34,000), and its suburbs.
31193 Region B includes a gage called “Below Priest Rapids, Washington.” This gage is located in
31194 Reach 14. Figure 3-195 presents the stream reaches, gages for which flood hazard categories
31195 have been defined by NWS, and large population centers that are relevant to FRM in Region B.

31196 Most areas experienced flooding in the first half of the twentieth century, but flood frequency
31197 has been reduced in more recent years due to FRM efforts, including installation of levees in
31198 some areas. The river communities that fall within Region B and the history of flooding in those
31199 communities is briefly summarized as follows:

- 31200 • R05 is combined with R14 and encompasses the McNary Dam reservoir (located in Region
31201 D) and the Below Priest Rapids gage (located in Region B), as well as the Tri-Cities area
31202 consisting of the majority of Richland, Kennewick, and Pasco, Washington, and surrounding
31203 suburbs. The boundary between Regions B and D runs through the Tri-Cities area. FRM is
31204 provided in these cities by federally constructed levees which are a part of the McNary Dam
31205 project completed in the early 1950s. There is little information available on historic
31206 flooding in this reach.
- 31207 • The R15 and R16 reaches are sparsely populated. Historic flood information is not available
31208 for these reaches. Agricultural fields are adjacent to the Priest Rapids reservoir (Columbia
31209 River) in R15. The Crescent Bar recreational area is adjacent to Lake Wanapum (Columbia
31210 River) in R16 near Trinidad, Washington. The gage at Below Priest Rapids is located at the
31211 downstream end of R15.
- 31212 • R17 includes the communities of Wenatchee and Rock Island, Washington. In R18 the
31213 communities of Entiat and Chelan, Washington are adjacent to the Columbia. Historically,
31214 flooding has occurred on the Wenatchee, Entiat and Chelan tributaries in these reaches.

- 31215 • The Methow and Okanogan Rivers flow into the Columbia in R19. Within this reach are the
 31216 communities of Pateros, Brewster and Bridgeport, Washington. Within R20, the
 31217 communities of Nespalem, Elmer City and Coulee Dam, Washington, are adjacent to Rufus
 31218 Woods Lake (Columbia River behind Chief Joseph Dam). Historic flooding of the Methow
 31219 and Okanogan Rivers in this reach has occurred.
- 31220 • R21 contains the communities of Grand Coulee, Inchelium, Gifford, Kettle Falls, Marcus and
 31221 Northport, Washington, as well as numerous other communities and recreational areas
 31222 nearby. The Colville Reservation is adjacent to Lake Roosevelt across the entire right
 31223 descending bank of this reach, and the Spokane Reservation is located on the left bank
 31224 above the confluence of the Spokane River. Historically, flooding from tributaries such as
 31225 the Colville River occurred in this reach.



31226
 31227 **Figure 3-195. Locations of Columbia River System Dams, Levees, and Other Dams in Region B**

31228 **Table 3-217. River Reaches in Region B**

Reach	Description
R05-R14 ^{1/1}	Columbia River - McNary Dam to Ice Harbor and Priest Rapids (Columbia RM 291–397) and Snake RM 0–8 ^{1/1}
R15	Columbia River - Priest Rapids Dam to Wanapum Dam (RM 397–415)
R16	Columbia River - Wanapum Dam to Rock Island Dam (RM 415–453)

Reach	Description
R17	Columbia River - Rock Island Dam to Rocky Reach Dam (RM 454–477)
R18	Columbia River - Rocky Reach Dam to Wells Dam (RM 475–516)
R19	Columbia River - Wells Dam to Chief Joseph Dam (RM 516–546)
R20	Columbia River - Chief Joseph Dam to Grand Coulee Dam (RM 546–597)
R21	Columbia River - Grand Coulee Dam to U.S.-Canada border (RM 597–748)

31229 1/ R05-R14 intersects Regions B and Region D. McNary Dam is in Region D and Snake RM 08 is in Region D.

31230 A major population center in this region is the Tri-Cities area that consists of Kennewick, Pasco,
 31231 and Richland, Washington. The estimated population of communities in Region B is 284,937, of
 31232 which 29,798 are in the FEMA flood hazard area.⁶ Region B rural areas include an estimated
 31233 population of 16,000 people, of which 7,000 are located in the FEMA flood hazard area. The
 31234 largest population center in the affected area is the Kennewick, Washington (population
 31235 82,000), and its suburbs. Communities that intersect the study area as well as populations that
 31236 fall within FEMA flood hazard areas in Region B are listed in Table 3-218. There are also a
 31237 number of tribes with reservation lands and off-reservation trust lands in Region B, including
 31238 the Confederated Tribes of the Colville Reservation (CTCR), the Spokane Tribe of Indians, and
 31239 the Coeur d’Alene Tribe.

31240 **Table 3-218. Communities within Region B 100- and 500-Year Floodplains**

Community	2017 Estimated Population ^{2/}	Estimated Population Within Flood Hazard Area ^{4/}	Reach	River – River Mile
Kennewick, WA ^{3/}	81,646	4,656	R05-14	Columbia – 334.5
West Pasco, WA ^{2/}	3,739	35	R05-14	Columbia – 334.8
Pasco, WA ^{3/}	73,013	390	R05-14	Columbia – 337.5
Richland, WA ^{3/}	56,243	1,244	R05-14	Columbia – 343.6
Desert Aire, WA ^{2/}	2,141	38	R15	Columbia – 402
Vantage, WA ^{2/}	80	0	R16	Columbia – 421
Rock Island, WA	1,015	211	R17	Columbia – 459.7
South Wenatchee, WA ^{2/}	1,681	507	R17	Columbia – 467.2
East Wenatchee, WA	13,983	3,959	R17	Columbia – 469.6
Wenatchee, WA	33,962	18,357	R17	Columbia – 471
Sunnyslope, WA ^{2/}	3,562	58	R17	Columbia – 473.8
Entiat, WA	1,223	0	R18	Columbia – 487.3
Chelan Falls, WA ^{2/}	365	0	R18	Columbia – 503.1
Chelan, WA	4,146	45	R18	Columbia – 503.9
Brewster, WA	2,343	75	R19	Columbia – 531.8
Bridgeport, WA	2,555	161	R19	Columbia – 544.9
Coulee Dam, WA	1,079	4	R20	Columbia – 596.9

⁶ Populations within the 1% annual chance exceedance (100-year) and 0.2% annual chance exceedance (500-year) flood zones were estimated with GIS software using U.S. Census block data in conjunction with FEMA FIRM data. Populations located outside of community boundaries but within the hydrologic and hydraulic modeling area are considered as rural.

Community	2017 Estimated Population ^{1/}	Estimated Population Within Flood Hazard Area ^{4/}	Reach	River – River Mile
Grand Coulee, WA	1,042	8	R21	Columbia – 597.6
Inchelium, WA ^{2/}	409	41	R21	Columbia – 681.4
Barney's Junction, WA ^{2/}	147	0	R21	Columbia – 705.9
Marcus, WA	193	0	R21	Columbia – 711.5
Barstow, WA ^{2/}	60	7	R21	Columbia – 718.3
Northport, WA	310	2	R21	Columbia – 738.8
Rural Areas	15,747	7,114	Multiple	
Total	284,937	29,798		

31241 1/ Source: U.S. Census Bureau (2017) or latest available data.

31242 2/ Source: ESRI data that is derived from U.S. Census data for unincorporated areas that are census-designated places.

31243 3/ Some portions of the Tri-Cities area are located in Region B and some in Region D. Reported populations are included
31244 in one region only (to avoid double counting).

31245 4/ Includes 1% and 0.2% annual chance exceedance flood hazard areas. Populations within the 1% annual chance
31246 exceedance (100-year) and 0.2% annual chance exceedance (500-year) flood zones were estimated with GIS software
31247 using U.S. Census block data in conjunction with FEMA flood insurance rate map (FIRM) data. Populations located
31248 outside of community boundaries but within the hydrologic and hydraulic modeling area are considered as rural.

31249 **3.9.3.3 Region C**

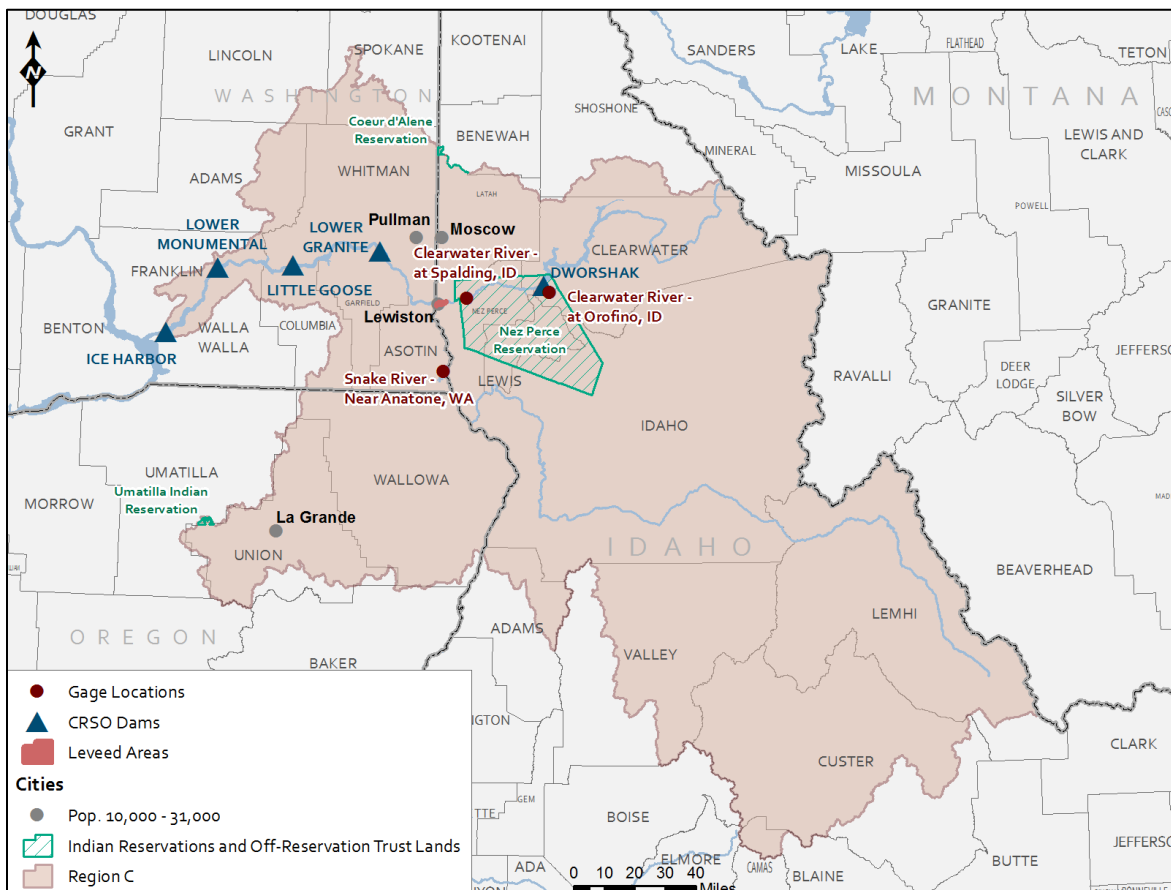
31250 Region C includes much of the lower Snake portion of the Columbia Snake River system.

31251 Dworshak storage project is the only Federal project with storage in Region C. The river reaches
31252 that are relevant to the FRM analysis in Region C are shown in Table 3-219, and are consistent
31253 with those used in the H&H resources analysis. As noted above, this analysis uses flood gages
31254 along a subset of these reaches to characterize current flows and anticipated changes under
31255 the MOs. Region C includes three gages: Anatone, Washington; Orofino, Idaho; and Spalding,
31256 Idaho. Orofino Gage is on the mainstem of the Clearwater River a few miles above the
31257 confluence with the North Fork. The Spalding Gage is on the Clearwater downstream of Orofino
31258 and Dworshak. The Anatone gage is on the Snake River upstream of the Clearwater Confluence
31259 at Lewiston, Idaho. presents the stream reaches, gages for which flood hazard categories have
31260 been defined by NWS, and large population centers that are relevant to FRM in Region C.

31261 The river communities that fall within Region C and the history of flooding in those
31262 communities is briefly summarized as follows:

- 31263 • R06, R07 and R08 are sparsely populated reaches. There are grain terminals for marine
31264 loading, natural sites and recreational areas adjacent to the river. Historic flood information
31265 is not available for this area.
- 31266 • R09 includes Clarkston, Washington and Lewiston, Idaho, at the confluence of the Snake
31267 and Clearwater Rivers. There are levees at Clarkson and Lewiston that are intended to
31268 contain the Snake and Clearwater Rivers (including flood flows) and prevent flooding within
31269 the cities. These levees were built as part of the Lower Granite Project, which does not have
31270 an FRM project purpose. The levees have been referred to informally as flow conveyance
31271 levees and were designed to prevent flooding within the cities when the Lower Granite pool

31272 was filled in the 1970s. The area behind the levees contains highly developed industrial,
31273 commercial and residential property. R09 extends up the Snake River to Hells Canyon dam
31274 and up the Clearwater River to its confluence with the North Fork of the Clearwater
31275 (Dworshak Dam). From Lewiston to Dworshak Dam, the Clearwater has a long, narrow
31276 floodplain with roads and a railroad along the river and small areas of residential
31277 development, and includes the cities of Spalding and Orofino, Idaho, several unincorporated
31278 communities, and the Nez Perce Reservation along the entire stretch of the Clearwater.
31279 From Lewiston to Hells Canyon Dam the Snake River has a long, narrow floodplain that is
31280 includes the cities of Asotin, and Rogersberg, Washington. Flooding in R09 occurred in 1948
31281 at Clarkston, Washington and Lewiston, Idaho, and along the Clearwater to Orofino, Idaho,
31282 and in the Grand Ronde tributary, which flows into the Snake near Rogersberg, Washington.
31283 All three indicator gages are located in this reach (Figure 3-196).



31284 **Figure 3-196. Locations of Columbia River System Dams, Levees, and Other Dams in Region C**
31285

31286 **Table 3-219. River Reaches in Region C**

Reach	Description
R06	Snake River - Ice Harbor Dam to Lower Monumental Dam (RM 9–40)
R07	Snake River - Lower Monumental Dam to Little Goose Dam (RM 41–69)
R08	Snake River - Little Goose Dam to Lower Granite Dam (RM 70–106)
R09	Snake + Clearwater Rivers - Lower Granite Dam to Dworshak (Clearwater) (Snake RM 107–178), Clearwater RM 0–45)

31287 The estimated population of communities in Region C is approximately 53,000, of which just
31288 over 100 are within the FEMA-defined flood hazard area.⁷ The largest population center in the
31289 affected area are the cities of Lewiston and Clarkston, Idaho and suburbs. Communities that
31290 intersect the study area as well as populations that fall within these flood hazard areas in
31291 Region C, are listed in Table 3-220. Region C rural areas include an estimated population less
31292 than 2,000 people, of which approximately 90 are located in the flood hazard area. The Nez
31293 Perce Tribe has reservation lands in Region C, including an area overlapping with Dworshak.

31294 **Table 3-220. Population within the 100 and 500-Year Floodplains–Region C**

Community	2017 Estimated Population ^{1/}	Estimated Population Within Flood Hazard Area ^{3/}	Reach	River/River Mile
Lewiston, ID	32,820	0	R09	Clearwater - 4.1
Peck, ID	197	0	R09	Clearwater - 35.5
Orofino, ID	3,035	0	R09	Clearwater - 45.5
Clarkston, WA	7,396	0	R09	Snake - 139.7
West Clarkston-Highland, WA ^{2/}	2,265	0	R09	Snake - 141.9
Clarkston Heights-Vineland WA ^{2/}	6,537	0	R09	Snake - 143.3
Asotin, WA	1,295	145	R09	Snake - 146.6
Rural Areas	1,606	85	Multiple	
Total	53,545	145		

31295 ¹ Source: U.S. Census Bureau (2017) or latest available data.

31296 ² Source: ESRI data that is derived from U.S. Census data for unincorporated areas that are census-designated
31297 places.

31298 ³ Includes 1% and 0.2% annual chance exceedance flood hazard areas. Populations within the 1% annual chance
31299 exceedance (100-year) and 0.2% annual chance exceedance (500-year) flood zones were estimated with
31300 geographic information system (GIS) software using U.S. Census block data in conjunction with FEMA flood
31301 insurance rate map (FIRM) data. Populations located outside of community boundaries but within the hydrologic
31302 and hydraulic modeling area are considered as rural.

31303 **3.9.3.4 Region D**

31304 Region D includes the John Day storage project. The river reaches that are relevant to the FRM
31305 analysis in Region D are shown in Table 3-221 and are consistent with those utilized in the H&H
31306 resources analysis. As noted above, this analysis uses flood gages along a subset of these
31307 reaches to characterize current flows and anticipated changes under MOs. Region D includes six
31308 gages at Vancouver, Washington; St. Helens, Oregon; Woodland, Washington; Kelso,
31309 Washington; Longview, Washington; and Wauna, Oregon. All of these gages are located in
31310 Reach 1, which is the reach that contains the majority of the population in this region.
31311 Figure 3-197 presents the stream reaches, gages for which flood hazard categories have been
31312 defined by NWS, and large population centers that are relevant to FRM in Region D.

⁷ Populations within the 1% annual chance exceedance and 0.2% annual chance exceedance flood zones were estimated with GIS software using U.S. Census block data in conjunction with FEMA FIRM data. Populations located outside of community boundaries but within the hydrologic and hydraulic modeling area are considered as rural.

31313 The river communities that fall within Region D and the history of flooding in those
31314 communities is briefly summarized as follows:

- 31315 • R01 extends from the approximately RM 30 of the Columbia River up to Bonneville Dam,
31316 and includes the Willamette River up to Willamette Falls. This reach includes the cities of
31317 Portland, St. Helens, and Westport, Oregon, and Vancouver, Woodland, Kalama, Kelso and
31318 Longview, Washington, as well as many small communities, rural and agricultural areas.
31319 Within R01 there are 90,000 acres behind levees. These include 50 systems with 240 miles
31320 of levees. This reach has historically flooded many times in the past, with notable
31321 catastrophic flooding in 1894, 1948, 1956, 1964, 1996, and 1997.

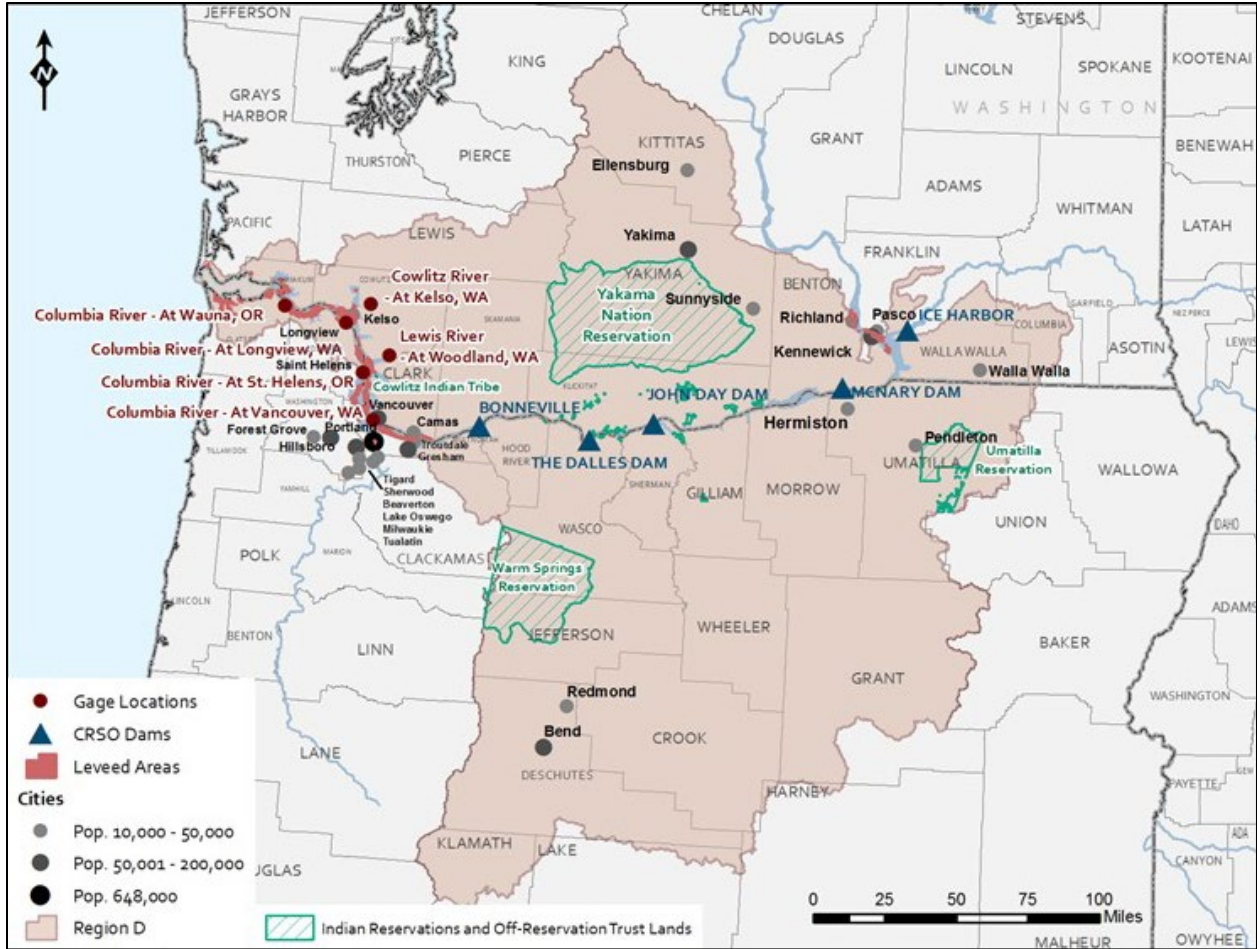
31322 The R02 consequence area includes the cities of Hood River and The Dalles, Oregon, and Bingen
31323 and Lyle Washington. R03 includes Biggs Junction and Rufus, Oregon, and Wishram and
31324 Maryhill, Washington. R04 includes Boardman and Umatilla, Oregon, as well as Lake Umatilla.

31325 Region D includes the major metropolitan area of Portland, Oregon, including suburbs, as well
31326 as Vancouver, Washington. It also includes the town of Longview, Washington, as well as The
31327 Dalles, Oregon. The total population of this area is approximately 1.4 million, with an estimated
31328 population within the FEMA-defined flood hazard area of 90,000.⁸ The largest population
31329 residing in the FEMA-defined flood hazard area is in Longview, Washington, where an
31330 estimated population of 33,000 resides in the flood hazard area. An additional 18,000 people in
31331 Portland, Oregon, also reside in the flood hazard area. Communities that intersect the study
31332 area as well as populations that fall within the flood hazard areas in Region D are listed in
31333 Table 3-222. Region D rural areas include an estimated population of 44,000 people, of which
31334 12,000 are located in the flood hazard area. There are also a number of tribes with reservation
31335 lands and off-reservation trust lands in Region D, including the Confederated Tribes and Bands
31336 of the Yakama Nation, the Cowlitz Indian Tribe, the Confederated Tribes of the Warm Springs
31337 Reservation of Oregon, and the Confederated Tribes of the Umatilla Indian Reservation.

31338 **Table 3-221. Region D Consequence Areas**

Reach	Description
R01	Below Bonneville Dam (Columbia RM 30–146)
R02	Columbia River - Bonneville Dam to The Dalles Dam (RM 146–192)
R03	Columbia River - The Dalles Dam to John Day Dam (RM 192–217)
R04	Columbia River - John Day Dam to McNary Dam (RM 217–291)

⁸ Populations within the 1% annual chance exceedance (100-year) and 0.2% annual chance exceedance (500-year) flood zones were estimated with GIS software using U.S. Census block data in conjunction with FEMA FIRM data. Populations located outside of community boundaries but within the hydrologic and hydraulic modeling area are considered as rural.



31339
31340 **Figure 3-197. Locations of Columbia River System Dams, Levees, and Other Dams in Region D**

31341 **Table 3-222. Population within the 100 and 500-Year Floodplains–Region D**

Community	2017 Estimated Population ^{1/}	Estimated Population Within Flood Hazard Area ^{3/}	Reach	River Mile
Portland, OR	647,805	18,351	R01	Willamette – 17.3
Milwaukie, OR	20,801	1,176	R01	Willamette – 19.2
Lake Oswego, OR	39,196	211	R01	Willamette – 21.9
Oak Grove, OR	8,112	1,023	R01	Willamette – 22.4
Jennings Lodge, OR	7,315	522	R01	Willamette – 24.5
Gladstone, OR	12,207	1,674	R01	Willamette – 24.7
West Linn, OR	26,703	154	R01	Willamette – 25.9
Rosburg, WA ^{2/}	317	123	R01	Columbia – 29.6
Grays River, WA ^{2/}	263	109	R01	Columbia – 30
Skamokawa Valley, WA ^{2/}	449	218	R01	Columbia – 35.1
Cathlamet, WA	553	165	R01	Columbia – 38.2
Lower Elochoman, WA ^{2/}	185	22	R01	Columbia – 38.2
Upper Elochoman, WA ^{2/}	193	15	R01	Columbia – 38.2
East Cathlamet, WA ^{2/}	491	4	R01	Columbia – 41.7

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Community	2017 Estimated Population ^{1/}	Estimated Population Within Flood Hazard Area ^{3/}	Reach	River Mile
Westport, OR	321	11	R01	Columbia – 44.1
Puget Island, WA ^{2/}	831	816	R01	Columbia – 45.6
Clatskanie, OR	1,815	343	R01	Columbia – 50.4
Longview Heights, WA ^{2/}	3,851	30	R01	Columbia – 61.7
Castle Rock, WA	2,234	1,331	R01	Columbia – 64
West Side Highway, WA ^{2/}	5,517	3,129	R01	Columbia – 65.6
Longview, WA	37,602	33,389	R01	Columbia – 67.5
Kelso, WA	12,130	6,518	R01	Columbia – 69.5
Rainier, OR	2,126	13	R01	Columbia – 69.7
Prescott, OR	50	18	R01	Columbia – 72.6
Kalama, WA	2,687	67	R01	Columbia – 77.9
Woodland ,WA	6,138	5,429	R01	Columbia – 81.3
Deer Island, OR ^{2/}	294	74	R01	Columbia – 82.4
Columbia City, OR	2,031	11	R01	Columbia – 85.2
St. Helens, OR	13,701	607	R01	Columbia – 87.2
La Center, WA	3,218	46	R01	Columbia – 87.5
Warren, OR ^{2/}	1,787	17	R01	Columbia – 90
Scappoose, OR	7,262	2,046	R01	Columbia – 90.4
Ridgefield ,WA	7,959	119	R01	Columbia – 92.1
Cherry Grove, WA ^{2/}	546	32	R01	Columbia – 93.9
Felida, WA ^{2/}	7,385	51	R01	Columbia – 96.2
Mount Vista, WA ^{2/}	7,850	1	R01	Columbia – 96.2
Salmon Creek, WA ^{2/}	19,686	366	R01	Columbia – 96.7
Lake Shore, WA ^{2/}	6,571	194	R01	Columbia – 104.1
Barberton, WA ^{2/}	5,661	80	R01	Columbia – 105.5
Hazel Dell, WA ^{2/}	19,435	614	R01	Columbia – 105.5
Walnut Grove, WA ^{2/}	9,790	298	R01	Columbia – 105.5
Minnehaha, WA ^{2/}	9,771	109	R01	Columbia – 109
Five Corners, WA ^{2/}	18,159	453	R01	Columbia – 110.5
Vancouver, WA	175,673	4,010	R01	Columbia – 115.9
Gresham, OR	111,053	554	R01	Columbia – 118
Wood Village, OR	4,040	12	R01	Columbia – 119.6
Fairview, OR	9,475	2,285	R01	Columbia – 119.9
Camas, WA	23,331	464	R01	Columbia – 121.8
Troutdale, OR	16,554	276	R01	Columbia – 122.1
Washougal, WA	15,711	535	R01	Columbia – 124.4
North Bonneville, WA	999	182	R01	Columbia – 145.9
Stevenson, WA	1,555	16	R02	Columbia – 150.8
Cascade Locks, OR	1,166	15	R02	Columbia – 152
Carson, WA ^{2/}	2,279	0	R02	Columbia – 154.7

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Community	2017 Estimated Population ^{1/}	Estimated Population Within Flood Hazard Area ^{3/}	Reach	River Mile
Hood River, OR	7,686	0	R02	Columbia – 169.9
White Salmon, WA	2,552	4	R02	Columbia – 169.9
Bingen, WA	729	52	R02	Columbia – 172.1
Mosier, OR	458	6	R02	Columbia – 175.3
Lyle, WA ^{2/}	517	15	R02	Columbia – 181.1
Rowena, OR ^{2/}	187	0	R02	Columbia – 182.6
Dallesport, WA ^{2/}	1,202	10	R02	Columbia – 191.7
The Dalles, OR	15,646	33	R02	Columbia – 192
Biggs Junction, OR ^{2/}	22	0	R03	Columbia – 209.4
Maryhill, WA ^{2/}	61	0	R03	Columbia – 212.4
Rufus, OR	249	32	R03	Columbia – 214.3
Arlington, OR	583	18	R04	Columbia – 243.5
Roosevelt, WA ^{2/}	165	0	R04	Columbia – 245.8
Boardman, OR	3,329	0	R04	Columbia – 269.5
Irrigon, OR	1,783	0	R04	Columbia – 282.1
Umatilla, OR	7,132	2,088	R04	Columbia – 290.1
Burbank, WA ^{2/}	3,291	49	R05–14	Columbia – 322.5
Finley, WA ^{2/}	6,321	19	R05–14	Columbia – 327.1
West Richland, WA	14,596	36	R05–14	Columbia – 339.8
Rural Areas	44,078	12,357	Multiple	
Total	1,409,343	90,690		

31342 ¹ Source: U.S. Census Bureau (2017) or latest available data.

31343 ² Source: ESRI data that is derived from U.S. Census data for unincorporated areas that are census-designated places.
31344 Some portions of the Tri-Cities area are located in Region B and some are in Region D, but populations reported here
31345 for Burbank, Finley and West Richland are only included in Region D (to avoid double counting)

31346 ³ Includes 1% (100-year flood) and 0.2% (500-year flood) annual chance exceedance flood hazard areas.

31347 Populations within the 1% annual chance exceedance (100-year) and 0.2% annual chance exceedance (500-year)

31348 flood zones were estimated with GIS software using U.S. Census block data in conjunction with FEMA FIRM data.

31349 Populations located outside of community boundaries but within the hydrologic and hydraulic modeling area are

31350 considered as rural.

31351 **3.9.4 Environmental Consequences**

31352 MOs could affect flood risk by changing river flows (measured by discharge in cfs), stages, and
31353 reservoir elevations (measured in feet above sea level [NAVD88]), as well as by changing system
31354 configuration (as would occur with the breaching of projects on the lower Snake River under
31355 MO3). These changes were evaluated to determine whether there would be a change in flood
31356 risk faced by communities, property, infrastructure, or levees in the Columbia River Basin under
31357 each alternative.

31358 **3.9.4.1 Effects Assessment Methodology**

31359 The flood risk analysis began by establishing the anticipated flood risk conditions under the No
31360 Action Alternative. Flood risk conditions were evaluated at a sample of gage locations
31361 throughout the CRSO study area. Annual peak stages at gage locations (except for Albeni Falls
31362 outflow location, where flows were used) were provided by H&H engineers for each of 5,000
31363 simulated events, based on period-of-record data, for each of the winter (November 1 to March
31364 31), spring (April 1 to July 31), and annual (November to July) time periods and for each of the
31365 MOs and the No Action Alternative. These peak figures were then compared to thresholds for
31366 flood hazards established by the NWS to evaluate whether flood risk would change under the
31367 MOs. Hydrologic modeling of anticipated river flows and stages were estimated at each gage
31368 for each alternative. Flood risks are measured in terms of the likelihood that established flood
31369 thresholds would be exceeded, which is called the annual exceedance probability (AEP).⁹

31370 **LOCATIONS USED IN THIS ANALYSIS**

31371 The analysis used flow and stage estimates at 14 river gages. These gage locations were
31372 selected because they provide good representative sample locations throughout the study
31373 area. The gages are either located near populated areas or are gage locations commonly used
31374 to communicate estimated flood levels for a given area.

31375 The NWS, the U.S. Geological Survey, the Corps, and Reclamation work jointly to gather and
31376 disseminate data to inform the public about river conditions at significant locations. The gage
31377 location data includes historical stage or flow conditions, which are communicated to the public
31378 through the NWS's Advanced Hydrologic Prediction Service (water.weather.gov/ahps). These
31379 gages are useful in assessing the thresholds at which river and possible flood conditions
31380 become hazardous. The gage locations are shown in Figure 3-192 NWS specifies flows or
31381 elevations (stages) that are associated with four different flood categories: action stage, flood
31382 stage, moderate flood stage, and major flood stage (defined in Section 3.9.3, *Affected*
31383 *Environment*). The thresholds for each NWS flood hazard category for each gage location are
31384 presented in Table 3-223. The thresholds are measured in either elevation (feet) or flow (cfs).

⁹ AEP is the reciprocal of what is often referred to as the "return period." The return period (or recurrence interval) of an annual maximum flood event has a return period of X years if its magnitude is equaled or exceeded once, on average, every X years. As an example, a 1% return period (1/100) means that there is a 1% probability of occurring or being exceeded in any one year.

31385 **Table 3-223. Thresholds for Flood Hazard Categories**

Region	H&H Reach	Gage or Other Consequence Source	Stages in NAVD88 datum feet (unless otherwise noted)			
			Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
A	R22 and R23	Pend Oreille River Outflow from Albeni Falls ^{1/}	85 ^{1/}	95 ^{1/}	115 ^{1/}	130 ^{1/}
A	R24	Lake Pend Oreille near Hope, ID	2,066.6	2,067.5	2,070	2,073
A	R25 to R27	Clark Fork near Plains, MT	2,467.9	2,468.9	2,470.9	2,472.4
A	R28	Columbia Falls, MT, Gage	2,993.8	2,994.3	2,999.3	3,003.3
A	R29	Bonnars Ferry, ID, Gage	1,760.8	1,767.8	1,773.8	1,781.8
B	R21	Grand Coulee Pool	Simulations do not exceed normal full pool level of 1,290 ft (NGVD29) under MOs			
B	R20	Chief Joseph Pool	Simulations do not exceed normal full pool level of 956 ft (NGVD29) under MOs			
B	R19	Wells Pool	Simulations do not exceed normal full pool level of 781 ft (NGVD29) under MOs			
B	R18	Rocky Reach Pool	Simulations do not exceed normal full pool level of 707 ft (NGVD29) under MOs			
B	R17	Rock Island Pool	Simulations do not exceed normal full pool level of 613 ft (NGVD29) under MOs			
B	R16	Wanapum Pool	Simulations do not exceed normal full pool level of 570 ft (NGVD29) under MOs			
B	R15	Priest Rapids Pool	Simulations do not exceed normal full pool level of 488 ft (NGVD29) under MOs			
B	R14	Below Priest Rapids, WA, Gage	424.3	425.3	426.3	427.3
C	R06	Ice Harbor Pool	Simulations do not exceed normal full pool level of 440 ft (NGVD29) under MOs			
C	R07	Lower Monumental Pool	Simulations do not exceed normal full pool level of 540 ft (NGVD29) under MOs			
C	R08	Little Goose Pool	Simulations do not exceed normal full pool level of 638 ft (NGVD29) under MOs			
C	R09	Anatone, WA Gage	829.2	830.2	833.2	834.2
C	R09	Orofino, ID Gage	1,010.2	1,011.2	1,012.7	1,014.2
C	R09	Spalding, ID Gage	790.9	791.9	792.9	793.3
D	R02	Bonneville Pool	Simulations do not exceed normal full pool level of 77 ft (NGVD29) under MOs			
D	R03	The Dalles Pool	Simulations do not exceed normal full pool level of 160 ft (NGVD29) under MOs			
D	R04	John Day Pool	Simulations do not exceed normal full pool level of 268 ft (NGVD29) under any alternative			
D	R05	McNary Pool	Simulations do not exceed normal full pool level of 340 ft (NGVD29) under MOs			
D	R01	Vancouver, WA	20.1	21.1	25.1	30.1
D	R01	St. Helens, OR	18.7	19.7	22.2	25.2
D	R01	Woodland, WA	22	24	- ^{2/}	28

Region	H&H Reach	Gage or Other Consequence Source	Stages in NAVD88 datum feet (unless otherwise noted)			
			Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
D	R01	Kelso, WA	19.5	21.5	24.5	26.5
D	R01	Longview, WA	15	16.5	18	21
D	R01	Wauna, OR	13	13.5	– ^{2/}	14.5

31386 Note: Vertical datum for stages was adjusted to NAVD88 from NWS datum (typically NGVD29) where applicable
31387 using National Geodetic Survey conversion factors.

31388 1/ Flow thresholds are in thousands of cfs (kcfs).

31389 2/No threshold defined.

31390 Source:

31391 3 (A) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=alfw1>

31392 4 (A) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=plnm8>

31393 2 (A) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=cfmm8>

31394 1 (A) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=bfei1>

31395 5 (B) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=prdw1>

31396 8 (C) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=anaw1>

31397 7 (C) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=orfi1>

31398 6 (C) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=spdi1>

31399 9 (D) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=vapw1>

31400 10 (D) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=shno3>

31401 11 (D) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=lrww1>

31402 13 (D) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=kelw1>

31403 12 (D) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=lopw1>

31404 14 (D) <https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&qage=wauo3>

31405 EVALUATING ANNUAL EXCEEDANCE PROBABILITY FOR FLOOD HAZARDS

31406 For each gage, flood risk changes were identified for the No Action Alternative and each MO
31407 using the metric of AEP. As described previously, AEP is the probability of a given river stage or
31408 flow (e.g., flood stage) being exceeded in a given year. AEPs were identified at each location for
31409 four flood hazard categories (action stage, flood stage, moderate stage, and major stage, as
31410 defined in Section 3.9.3, *Affected Environment*,) for the No Action Alternative and each MO. The
31411 differences between AEP in each of the MOs and the No Action Alternative were the primary
31412 metric used to evaluate changes in flood risk effects. For example, using the flood stage
31413 threshold of 1,011.2 feet shown for the Orofino, Idaho, gage in Reach 09 in Table 3-226, the
31414 flood stage AEP for the No Action Alternative at this location is 13 percent as shown in Table 3-
31415 226. This 13 percent AEP is derived by counting the number of times the stage elevation of
31416 1,011.2 feet is exceeded at this location across the 5,000 events described previously in this
31417 paragraph. The same methodology is used to find the AEP for each of the MOs, at each of the
31418 NWS thresholds. The AEPs of the multiple objective alternatives are then compared to the AEP
31419 of the No Action Alternative to determine if there is any change in AEP between them. For the
31420 Orofino, Idaho, gage location used in the example above, Table 8 in Appendix K, *Flood Risk*
31421 *Management*, shows that there is no change in flood stage AEP between the No Action
31422 Alternative and MO1.

31423 This analysis uses peak annual and peak seasonal results from the 5,000-run Monte Carlo (M-C)
31424 simulations of the ResSim model and the flow-stage transformation tool. These modeling tools
31425 are described in detail in Appendix B, *Hydrology and Hydraulics*.

31426 The accuracy of AEP results from the H&H model is uncertain for very rare flooding conditions,
31427 defined in this analysis as less than 1 percent AEP. Changes that may occur in the less than 1
31428 percent AEP are described qualitatively, when appropriate. Similarly, changes in AEP at a given
31429 location and stage are assumed to be accurate at approximately 1 percent (due to modeling
31430 capabilities), thus change values are reported to the whole percent. Additional notes on AEP
31431 results, such as limitations of use and model anomalies, are included in Appendix B.

31432 Adjustments to the flood risk analysis and results linked to model anomalies are highlighted in
31433 Appendix B.

31434 **3.9.4.2 No Action Alternative**

31435 Anticipated future flood risk under the No Action Alternative is assumed to be consistent with
31436 current conditions, which were modeled using the statistical method described above.¹⁰ The
31437 analysis incorporates the historical hydrologic record, adjusted to accommodate additional low
31438 probability extreme events, as well as other factors, as described in the Appendix B. The No
31439 Action Alternative is intended to be a reasonable approximation of current conditions suitable
31440 for the comparative analysis employed in this EIS.

31441 Flood risk, as measured in AEP for each flood hazard category (action stage, flood stage,
31442 moderate flood stage, and major flood stage) at each gage location, is described by region and
31443 by location in the following sections.

31444 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

31445 As described in Section 3.9.3, *Affected Environment*, Region A is relatively rural, with an
31446 estimated total current population of 78,000, and a population of approximately 10,000 within
31447 the flood hazard area, most of which reside near Kalispell and Evergreen, Montana.¹¹ Region A
31448 has five gage locations used for this evaluation: Pend Oreille River Outflow from Below Albeni
31449 Falls; Lake Pend Oreille near Hope, Idaho; Clark Fork near Plains, Montana; Columbia Falls,
31450 Montana; and Bonners Ferry, Idaho. The flood risk AEPs for each flood stage for these gages
31451 under the No Action Alternative are summarized in Table 3-224. As shown, the Pend Oreille
31452 River Outflow from Below Albeni Falls gage is anticipated to have the highest probability of
31453 exceeding the moderate and major flooding thresholds, relative to the other locations shown in
31454 the table. Communities near this gage on reach R24 include Clark Fork, Dover, Hope, East Hope,
31455 Kootenai, Ponderay, Priest River, and Sandpoint, Idaho. The areas around the Columbia Falls,
31456 Montana, gage have a high probability of exceeding flood stage, relative to the other locations
31457 in the table. These comparisons are not intended to quantify the differences in risk across

¹⁰ Please refer to Chapter 4, *Climate*, for a discussion of other factors that may affect future flood risk conditions.

¹¹ Populations within the 1% annual chance exceedance and 0.2% annual chance exceedance flood zones were estimated with GIS software using U.S. Census block data in conjunction with FEMA FIRM data.

31458 regions, but rather to orient the reader to the table and the probabilities contained therein.
31459 Communities around the Columbia Falls, Montana, gage include Kalispell, Montana, and
31460 surrounding towns. While there have been some adjustments to Libby Dam operations since
31461 the Upper Columbia Alternative Flood Control and Fish Operations Final EIS (Corps, 2006), the
31462 current FRM conditions in the Kootenai/y basin as a result of Libby Dam's operation are
31463 generally similar to those conditions described in the Upper Columbia Alternative Flood Control
31464 and Fish Operations Final EIS.

31465 **Table 3-224. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in**
31466 **Region A, by Hazard Category**

H&H Reach	Gage Location	AEP			
		Action	Flood	Moderate Flood	Major Flood
R22 and R23	Pend Oreille River outflow from below Albeni Falls	50% ^{1/}	34% ^{1/}	9% ^{1/}	6% ^{1/}
R24	Lake Pend Oreille near Hope, ID	15%	11%	3%	<1%
R25 to R27	Clark Fork near Plains, MT	12%	5%	<1%	<1%
R28	Columbia Falls, MT	83%	73%	<1%	<1%
R29	Bonnars Ferry, ID	85%	<1%	<1%	<1%

31467 Note: Modeled estimates are rounded to the nearest whole percentage.

31468 ^{1/} Flow thresholds are in thousands of cfs (kcfs).

31469 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

31470 As described in the Section 3.9.3, *Affected Environment*, Region B is generally rural, with an
31471 estimated total current population of 285,000, and a population of approximately 30,000 within
31472 the flood hazard area. The largest population center in the affected area is the Kennewick,
31473 Washington, (population 81,000), and its suburbs.

31474 Region B has one gage: the Below Priest Rapids, Washington, gage. The flood risk AEPs for each
31475 flood stage for this gage under the No Action Alternative are summarized in Table 3-225. As
31476 shown, AEP is less than 1 percent for all thresholds at this gage under the No Action Alternative.

31477 As noted in the Table 3-225, the normal full pool elevations in the reaches upstream of Priest
31478 Rapids Dam are not exceeded in the simulation. This does not mean those elevations cannot be
31479 exceeded, but rather that the No Action Alternative does not affect flood hazards on the
31480 Columbia River from Priest Rapids Dam to the U.S.-Canada border.

31481 **Table 3-225. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in**
31482 **Region B, by Hazard Category**

H&H Reach	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
R14	Below Priest Rapids, WA	<1%	<1%	<1%	<1%

31483 Note: Modeled estimates are rounded to the nearest whole percentage.

31484 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
31485 **HARBOR DAMS**

31486 As described in Section 3.9.3, *Affected Environment*, Region C has an estimated total current
31487 population of 81,000 in 7 communities, but with a population of only 100 people within the
31488 flood hazard area. The largest population center in the affected area includes the cities of
31489 Lewiston, Idaho, and Clarkston, Washington, and surrounding suburbs.

31490 Region C has three gage locations: Anatone, Washington; Orofino, Idaho; and Spalding, Idaho.
31491 The flood risk AEPs for each flood stage for each gage under the No Action Alternative are
31492 summarized in Table 3-226. As shown, the Spalding gage on the Clearwater River exhibits the
31493 highest risk of moderate and major flooding under the No Action Alternative. However, as
31494 noted above, little population resides in the flood hazard area in this region. As shown in the
31495 Table 3-226, the normal full pool elevations in reaches R06, R07, and R08 are not exceeded
31496 under any alternative simulation. This does not mean those elevations cannot be exceeded, but
31497 rather that MOs do not affect flood hazards in these reaches.

31498 **Table 3-226. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in**
31499 **Region C, by Hazard Category**

H & H Reach	Gage Locations	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
R09	Anatone, WA	28%	14%	2%	2%
R09	Orofino, ID	20%	13%	3%	<1%
R09	Spalding, ID	57%	41%	28%	23%

31500 Note: Modeled estimates are rounded to the nearest whole percentage.

31501 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

31502 Region D has six gage locations: Vancouver, Washington; St. Helens, Oregon; Woodland,
31503 Washington; Kelso, Washington; Longview, Washington; and Wauna, Oregon. All of these gages
31504 are located near the Portland metropolitan area or downstream. The flood risk AEPs for each
31505 flood stage for these gages under the No Action Alternative are summarized in Table 3-227. The
31506 AEP for winter and spring events are shown separately for consequence locations in Region D.
31507 Winter events are those modeled to occur from November 1 to March 31, while spring events
31508 are those occurring from April 1 to July 31. Winter high-water events are commonly the result
31509 of extended periods of precipitation producing historically higher stages but for a lesser
31510 duration than spring events. Spring high-water events typically have a longer duration as late-
31511 season lower elevation snow is followed by heavy rain. As shown, the gages at Vancouver,
31512 Washington, and St. Helens, Oregon, exhibit the highest risk of moderate and major flooding
31513 under the No Action Alternative.

31514 As noted in Table 3-227, the normal full pool elevations in reaches R02, R03, R04 and R05 are
31515 not exceeded under any alternative simulation. This does not mean those elevations cannot be
31516 exceeded, but rather that MOs do not affect flood hazards in these reaches.

31517 **Table 3-227. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in**
31518 **Region D, by Hazard Category**

H&H Reach	Gage Locations	Season	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
R01	Vancouver, WA	Annual	43%	32%	11%	3%
R01	Vancouver, WA	Winter	38%	28%	10%	3%
R01	Vancouver, WA	Spring	22%	14%	2%	<1%
R01	St. Helens, OR	Annual	26%	16%	11%	6%
R01	St. Helens, OR	Winter	23%	14%	10%	5%
R01	St. Helens, OR	Spring	9%	6%	1%	<1%
R01	Woodland, WA	Annual	45%	32%	–	12%
R01	Woodland, WA	Winter	45%	32%	–	12%
R01	Woodland, WA	Spring	3%	<1%	–	<1%
R01	Kelso, WA	Annual	53%	19%	7%	6%
R01	Kelso, WA	Winter	49%	17%	6%	5%
R01	Kelso, WA	Spring	11%	2%	1%	<1%
R01	Longview, WA	Annual	24%	12%	8%	3%
R01	Longview, WA	Winter	22%	12%	8%	3%
R01	Longview, WA	Spring	9%	2%	<1%	<1%
R01	Wauna, OR	Annual	4%	3%	–	3%
R01	Wauna, OR	Winter	3%	%	–	3%
R01	Wauna, OR	Spring	<1%	0%	–	0%

31519 Note: Modeled estimates are rounded to the nearest whole percentage.

31520 Source: NWS hydrograph data and H&H analysis

31521 **SUMMARY OF EFFECTS**

31522 An estimated 1.8 million people currently reside in communities that have populations in the
31523 flood hazard areas of the CRSO EIS analysis. Of this total, approximately 7 percent reside in
31524 flood hazard areas.¹² Most of the total population and population within the flood hazard areas
31525 are in Region D.

31526 **3.9.4.3 Multiple Objective Alternative 1**

31527 This section describes changes in flood risk that would be anticipated under MO1, as measured
31528 in terms of changes in AEP from the No Action Alternative. Detailed changes in AEP are
31529 presented in Appendix K, *Flood Risk Management*.

¹² Populations within the 1% annual chance exceedance and 0.2% annual chance exceedance flood zones were estimated with GIS software using U.S. Census block data in conjunction with FEMA FIRM data.

31530 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

31531 There is little change anticipated to AEP in Region A under MO1. Additionally, under some flow
31532 conditions, flood risk is anticipated to decrease as a result of a decrease in the probability of
31533 flooding (refer to Table 6 of Appendix K, *Flood Risk Management*).

31534 No effect is anticipated to flood risk in the Kootenai River Basin within Region A under MO1.
31535 Under typical to lower annual peak flow conditions, flood risk is anticipated to decrease in
31536 probability under this alternative. In particular, the probability of flooding at Bonners Ferry,
31537 Idaho, is anticipated to decrease by 6 percent under MO1 at the action stage. This is due to a
31538 variety of operational measures at Libby Dam that result in deeper drafts earlier in the spring,
31539 including the *Modified Draft at Libby* measure. There are negligible changes to the probability
31540 of higher flood stage at the Bonners Ferry gage, thus no effect to flood risk conditions are
31541 expected. The U.S.-Canada border is downstream of Bonners Ferry. No effect to Canada is
31542 anticipated under MO1.

31543 On the Flathead River below Hungry Horse Dam, operational changes related to the *Hungry*
31544 *Horse Additional Water Supply* measure result in slightly decreased AEP at Columbia Falls,
31545 Montana, at the action and flood stage levels (of 1 to 2 percent) but negligible changes in
31546 probability at the larger flood stages leading to no effect on flood risk conditions.

31547 Related to the change at Hungry Horse, some minor decreases in flood risk (1 to 2 percent) are
31548 evident in the action and moderate flood conditions on the Pend Oreille River outflow from
31549 below Albeni Falls. There are no changes in flood risk at the Clark Fork gage near Plains,
31550 Montana, for any of the alternatives. Detailed tables are presented in Appendix K, *Flood Risk*
31551 *Management*. No effect to the Canadian part of the Pend Oreille is anticipated under MO1.

31552 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

31553 No changes to flood risk are anticipated in Region B under MO1.

31554 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
31555 **HARBOR DAMS**

31556 No changes to flood risk are anticipated in Region C under MO1.

31557 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

31558 Under MO1, it is anticipated that there are minor decreases in flood risk in Region D. In
31559 particular, there are negligible changes at the action stages and minor decreases at higher flood
31560 stages. Due to the *Winter System FRM Space* measure at Grand Coulee Dam, which results in
31561 more storage in December and January in order to reduce Columbia River flows coincident with
31562 peak flood conditions in the Portland/Vancouver area in reach R01, winter and annual peak
31563 flows are 1 to 4 percent lower for larger flood conditions near the mainstem Columbia River.
31564 The Vancouver, Washington, gage shows a decrease in flood risk at the action and flood stages
31565 of 1 to 2 percent. Similar decreases are seen downstream at the St. Helens, Oregon, and

31566 Longview, Washington, gages. Changes in flood risk at the Woodland and Kelso, Washington,
31567 gages would be similar to but likely smaller than those on the mainstem Columbia River
31568 downstream.¹³ Detailed tables are presented in Appendix K, *Flood Risk Management*.

31569 **SUMMARY OF EFFECTS**

31570 No increases in flood risk are anticipated as a result of MO1. Minor decreases in flood risk are
31571 expected in some areas, especially Region D. The primary measure that causes this decrease
31572 would be the *Winter System FRM Space* measure.

31573 **3.9.4.4 Multiple Objective Alternative 2**

31574 This section describes changes in flood risk, as measured in terms of changes in AEP from the
31575 No Action Alternative, for MO2. Detailed changes in AEP are presented in Appendix K, *Flood*
31576 *Risk Management*.

31577 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

31578 Overall, there is little change to flood risk anticipated under MO2 in Region A. Changes in flood
31579 risk in the Kootenai River Basin under MO2 are expected to be similar to those under MO1. At
31580 the Bonners Ferry, Idaho, gage, negligible changes are expected at flood stages, and there is a 7
31581 percent decrease expected in AEP at the action stage primarily due to the *Modified Draft at*
31582 *Libby* measure. There are no anticipated changes in flood risk in the Flathead and Pend Oreille
31583 River Basins under MO2.¹⁴ No effect to Canada is anticipated downstream of Bonners Ferry
31584 under MO2. No effect to the Canadian part of the Pend Oreille is anticipated under MO2.

31585 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

31586 No changes to flood risk are anticipated under MO2 in Region B. Detailed tables are presented
31587 in Appendix K, *Flood Risk Management*.

31588 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE** 31589 **HARBOR DAMS**

31590 Some changes in flood risk are anticipated under MO2 in Region C, although the changes are
31591 minor and would primarily affect AEP at lower action levels. The *Slightly Deeper Draft for*
31592 *Hydropower* measure would result in increased outflow from Dworshak, which would result in

¹³ AEP calculated at the Woodland and Kelso gages includes some model anomalies and should not be used directly. Stage on these relatively steep reaches is sensitive to changes in the downstream water level, and changes in AEP water levels can be more reflective of the random variable of event timing and peak coincidence than actual expected changes in mainstem Columbia River flows.

¹⁴ H&H model output shows increased peak flows; however, these changes are a modeling artifact related to modeled refill logic in the ResSim model made during the simulations of the *Slightly Deeper Draft for Hydropower* measure. If any change, flood risk would be expected to be lower due to typically being drafted deeper in the Hungry Horse Reservoir during the spring months.

31593 higher peak flows during typical, non-flood years. No changes in AEP are expected during
31594 potential flood years.¹⁴ Detailed tables are presented in Appendix K, *Flood Risk Management*.

31595 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

31596 There is little change anticipated to flood risk in Region D under MO2. Changes in flood risk in
31597 Region D under MO2 are anticipated to be similar to those under MO1, largely due to the
31598 *Winter System FRM Space* measure at Grand Coulee Dam. This measure results in more storage
31599 in December and January in order to reduce Columbia River flows coincident with peak flood
31600 conditions in the Portland/Vancouver area in reach R01. As a result, winter and annual peak
31601 flows are 1 to 4 percent lower for larger flood conditions near the mainstem Columbia River.
31602 The Vancouver, Washington, gage shows a decrease in flood risk at the action and flood stages
31603 of 1 to 2 percent, and negligible changes at the moderate and major flood stages. Similar
31604 changes are seen downstream at the St. Helens, Oregon, and Longview, Washington, gages.
31605 Changes in flood risk at the Woodland and Kelso, Washington, gages would be similar to but
31606 likely smaller than those on the mainstem Columbia River downstream.¹⁵ Detailed tables of AEP
31607 changes are presented in Appendix K, *Flood Risk Management*.

31608 **SUMMARY OF EFFECTS**

31609 No increases in flood risk are anticipated as a result of MO2. Some modeling anomalies related
31610 to refill logic in the model appear to show minor increases at the Columbia Falls, Montana,
31611 gage. However, if any change, flood risk would be expected to be lower due to typically being
31612 drafted deeper in the Hungry Horse Reservoir during the spring months. Minor decreases in
31613 flood risk are expected in some areas, especially Region D.

31614 **3.9.4.5 Multiple Objective Alternative 3**

31615 This section describes changes in flood risk, as measured in terms of changes in AEP from the
31616 No Action Alternative, for MO3. Detailed changes in AEP are presented in Appendix K, *Flood*
31617 *Risk Management*.

31618 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

31619 There is little change to flood risk anticipated under MO3. Additionally, under some flow
31620 conditions, as shown in Table 14 of Appendix K, *Flood Risk Management*, flood risk is
31621 anticipated to decrease in probability at some locations. In particular, the risk of flooding at
31622 Bonners Ferry, Idaho, is anticipated to decrease by 7 percent under MO3 at the action stage.
31623 Flood risk is anticipated to be reduced by 1 percent at the action stage and 2 percent at the
31624 flood stage at Columbia Falls, Montana. Detailed tables are presented in Appendix K, *Flood Risk*

¹⁵ AEP calculated at the Woodland and Kelso gages reflects some model anomalies. Stage on these relatively steep reaches is sensitive to changes in the downstream water level. Given this, changes in water levels and associated AEP changes may be more reflective of the random variable of event timing and peak coincidence than actual expected changes in mainstem Columbia River flows.

31625 *Management*. No effect to Canada is anticipated downstream of Bonners Ferry under MO3. No
31626 effect to the Canadian part of the Pend Oreille is anticipated under MO3.

31627 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

31628 No changes to flood risk are anticipated in Region B under MO3.

31629 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
31630 **HARBOR DAMS**

31631 MO3 would generally reduce river stages from the draining of Lower Granite Reservoir and the
31632 breaching of the other lower Snake River dams. Recognizing that levees exist at Clarkston and
31633 Lewiston, it is expected that when river stages decrease, flood risk would also decrease.
31634 Additional analysis would be required as part of an engineering design study to determine
31635 future levee needs and associated O&M requirements. Overall, in Region C under MO3, no
31636 effect to flood risk is expected.¹⁶ Detailed tables are presented in Appendix K, *Flood Risk*
31637 *Management*. There are levees at Clarkson and Lewiston that are intended to contain the Snake
31638 and Clearwater Rivers (including flood flows) and prevent flooding within the cities. These
31639 levees were built as part of the Lower Granite project, which does not have an FRM project
31640 purpose. The levees have been referred to informally as flow conveyance levees and were
31641 designed to prevent flooding within the cities when the Lower Granite pool was filled in the
31642 1970s. The area behind the levees contains highly developed industrial, commercial, and
31643 residential property

31644 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

31645 There is little change anticipated to flood risk in Region D under MO3. Due to the *Winter System*
31646 *FRM Space* measure at Grand Coulee Dam, which results in more storage in December and
31647 January in order to reduce Columbia River flows coincident with peak flood conditions in the
31648 Portland/Vancouver area in reach R01, winter and annual peak flows would be lower for larger
31649 flood conditions near the mainstem Columbia River. Under flow conditions at some locations as
31650 shown in Table 17 of Appendix K, *Flood Risk Management*, flood risk is anticipated to decrease
31651 in probability by 1 to 2 percent. Table 17 also shows estimates that flood risk may increase by 1
31652 percent at the Wauna, Kelso, and Woodland gages in some flood conditions; however, this
31653 slight increase is likely due to model anomalies.¹⁷ Detailed tables for all alternatives and gage
31654 locations are presented in Appendix K, *Flood Risk Management*.

16 Dworshak has the same operational ruleset in the No Action Alternative as MO3, therefore, any changes in the modeling results are a modeling artifact likely related to system refill timing changes.

17 Woodland and Kelso gages reflect some model anomalies given the unique topographic and hydraulic conditions in the area. Stage on these relatively steep reaches are sensitive to changes in the downstream water level, and changes in AEP water levels can be more reflective of the random variable of event timing and peak coincidence than actual expected.

31655 **SUMMARY OF EFFECTS**

31656 Under MO3, the draining of Lower Granite Reservoir and breaching of the lower Snake River
31657 dams would result in no anticipated change in flood risk. The Spalding, Idaho, gage shows a
31658 minor increase in flood risk at the action stage, while minor decreases in flood risk may occur in
31659 other areas.

31660 **3.9.4.6 Multiple Objective Alternative 4**

31661 This section describes changes in flood risk, as measured in terms of changes in AEP from the
31662 No Action Alternative, for MO4. Detailed changes in AEP are presented in Appendix K, *Flood*
31663 *Risk Management*.

31664 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

31665 There is little change anticipated to AEP in Region A under MO4. Additionally, under flow
31666 conditions at some locations as shown in Table 18 of Appendix K, *Flood Risk Management*,
31667 flood risk is anticipated to decrease in probability. At the Pend Oreille River Outflow from Below
31668 Albeni Falls gage, a 1 percent increase for the action and major flood stages is anticipated under
31669 this alternative. The risk of flooding at Bonners Ferry, Idaho, is anticipated to decrease by 5
31670 percent under MO4 at the action stage primarily due to the *Modified Draft at Libby* measure.
31671 Detailed tables are presented in Appendix K, *Flood Risk Management*. The risk of flooding at the
31672 flood stage is anticipated to decrease by 2 percent at the Columbia Falls, Montana, gage. No
31673 effect to Canada is anticipated downstream of Bonners Ferry under MO4. No effect to the
31674 Canadian part of the Pend Oreille is anticipated under MO4.

31675 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

31676 No changes to flood risk are anticipated in Region B under MO4.

31677 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
31678 **HARBOR DAMS**

31679 No effect to flood risk is expected in Region C under MO4. At the Spalding, Idaho, gage, flood
31680 risk modeling shows no change. Detailed tables are presented in Appendix K, *Flood Risk*
31681 *Management*.

31682 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

31683 There is little change anticipated to flood risk in Region D under MO4. Changes in flood risk in
31684 Region D under MO4 are anticipated to be similar to those under MO1, largely due to both
31685 alternatives including the *Winter System FRM Space* measure at Grand Coulee Dam. This
31686 measure results in more storage in December and January in order to reduce Columbia River
31687 flows coincident with peak flood conditions in the Portland/Vancouver area in reach R01. As a
31688 result, winter and annual peak flows are 1 to 4 percent lower for larger flood conditions near
31689 the mainstem Columbia River. The Vancouver, Washington, gage shows a decrease in flood risk

31690 at the action and flood stages of 1 to 2 percent, and negligible changes at the moderate and
31691 major flood stages. Similar changes are seen downstream at the St. Helens, Oregon, and
31692 Longview, Washington, gages. Changes in flood risk at the Woodland and Kelso, Washington,
31693 gages would be similar to but likely smaller than those on the mainstem Columbia River
31694 downstream.¹⁸ Detailed tables of AEP changes are presented in Appendix K, *Flood Risk*
31695 *Management*.

31696 **SUMMARY OF EFFECTS**

31697 No changes flood risk are anticipated as a result of MO4. Minor decreases in flood risk may
31698 occur in some areas, especially in Region D.

31699 **3.9.5 Tribal Interests**

31700 There are also a number of tribes with reservation lands and off-reservation trust lands in the
31701 study area, including the Kootenai Tribe of Idaho, the Confederated Salish and Kootenai Tribes,
31702 and the Kalispel Tribe of Indians in Region A; the CTCR, the Spokane Tribe of Indians, and
31703 the Coeur d'Alene Tribe in Region B; Nez Perce in Region C, the Confederated Tribes and Bands
31704 of the Yakama Nation, the Cowlitz Indian Tribe, the Confederated Tribes of the Warm Springs
31705 Reservation of Oregon, and the Confederated Tribes of the Umatilla Indian Reservation in
31706 Region D.

31707 Analysis of flood risk (Section 3.9.4) indicates that overall there would be no change to flood
31708 risk in the study area under any MO relative to the No Action Alternative. As such, there would
31709 be no change from the No Action Alternative for tribal interests or lands in terms of flood risk.

¹⁸ AEP calculated at the Woodland and Kelso gages reflects some model anomalies. Stage on these relatively steep reaches is sensitive to changes in the downstream water level. Given this, changes in water levels and associated AEP changes may be more reflective of the random variable of event timing and peak coincidence than actual expected changes in mainstem Columbia River flows.

31710 **3.10 NAVIGATION AND TRANSPORTATION**

31711 The MOs have the potential to affect commercial navigation activities, commercial cruise line
31712 and ferry operations, and the broader transportation system, including roads and railways.
31713 Dredging and other ongoing maintenance of the navigation channel may also be affected by
31714 implementation of the alternatives. This section describes these activities and potential effects.

31715 **3.10.1 Introduction and Background**

31716 River navigation has provided a means of transportation, trade, commerce, and economic
31717 development in the Northwest dating back to the original Native American occupants
31718 thousands of years ago. The natural flow of the river presented significant challenges for
31719 navigation and transportation on the river, given the wide fluctuations in water volumes
31720 between the dry summer months and the winter/spring melt. The construction of the
31721 locks/dams on the Columbia and Snake Rivers, beginning in 1933 on Bonneville Dam and ending
31722 in 1975 with Lower Granite on the Snake River, allowed for safer operation of large vessels,
31723 lower transportation costs, and more consistent river conditions.

31724 The inland river navigation on the Columbia and Snake Rivers has served an important role in
31725 the overall, multi-modal transportation system in the Columbia River basin. Barge
31726 transportation is ideally well-suited for movement of large quantities and for heavy
31727 commodities. Barges can accommodate bulky, oversized shipments that would be challenging
31728 to move by rail and/or road. Additionally, barges have low-energy demands, requiring less fuel
31729 per ton of commodity shipped compared to alternate shipping modes.

31730 The presence of inland water transportation and the multi-modal system serves both
31731 complementary and competitive forces for businesses and shippers moving freight. It is
31732 complementary given that all volumes of commodities that move on the river system begin and
31733 end somewhere beyond the river, requiring other modes of transport, such as truck and rail, for
31734 river transport to exist or be viable. This is evident for much of the grain products that move
31735 down the Snake River that originate via truck or rail. It is competitive by providing an
31736 alternative option for freight to use different multi-mode combinations, thereby applying
31737 competitive market pressure to lower transportation rates, while continuing to provide a
31738 valuable service.

31739 Many changes have occurred over time to the combination of freight services and the
31740 commodity mix of freight moving on the different segments of this river system. The lower
31741 Columbia River, with 43-foot draft, allows for bulk ocean and container carrier vessels and, until
31742 2015, was also a primary conduit for container freight accessing the Port of Portland's Terminal
31743 6. Prior to 2015, several ocean container lines called on the Port of Portland, including the
31744 South Korean carrier, Hanjin; the German-based carrier, Hapag-Lloyd; Puyallup, Washington-
31745 based Westwood Shipping; and others. The freight moving in these containers was primarily
31746 consumer durables, inbound containers arriving from Asia. Outbound export commodities
31747 included hay, paper products, frozen potatoes, dried fruit, and other high-value agricultural
31748 products. After 2015, the decision by the ocean container carriers to cease calling on the Port of

31749 Portland was due to a variety of factors, but was accelerated by an extended labor dispute
31750 between the International Longshore and Warehouse Union and the terminal operator that led
31751 to slow loading and unloading of ships and costly stops. It was also partly due to the evolution
31752 of the industry to begin using larger container vessels that required drafts too deep for the
31753 Columbia River ports. As a result, all of the container freight that previously moved through the
31754 Port of Portland recently shifted to the Ports of Tacoma and Seattle, Washington (Northwest
31755 Seaport Alliance 2018). However, it was recently announced that weekly container service using
31756 six 4,300 to 4,500 20-foot-equivalent-unit (TEU) vessels, will resume service in early 2020 at the
31757 Port of Portland. The full port rotation will be Yantian, Ningbo, Shanghai, Pusan, Vancouver,
31758 Seattle, Portland, Pusan, Kwangyang, and Yantian. While no service to the Snake River is
31759 currently anticipated, the potential exists for future expansion of this service (Port of Lewiston
31760 2019).

31761 While the loss of container services reduced container vessel freight moving on the lower
31762 Columbia and Snake Rivers, other changes led to significant increases in bulk ocean grain
31763 vessels calling at the lower Columbia River export terminals. Until the early 2000s, most of the
31764 grain being exported out of the Northwest arrived via barge (and some rail) out of the lower
31765 Columbia River, with primarily wheat exports using barge transport down the Snake River. The
31766 advent of the shuttle grain train (dedicated 110-unit hopper grain trains) and the increasing
31767 demand for protein in Asia (primarily China) led to several large investments by international
31768 grain merchants on the lower Columbia River as well as increasing volumes of soybeans, corn,
31769 wheat, and dried distillers grains being exported from the lower Columbia River ports while
31770 originating throughout the Midwest by rail. Soybean exports alone from Northwest ports
31771 increased from just below 40 million bushels in 1998 to 450 million bushels by 2016 (USDA
31772 Grain Inspections 2018).

31773 The primary grain export terminals receiving shuttle trains from the Midwest on the lower
31774 Columbia River include:

- 31775 • **Longview Export Grain Terminal, Longview, Washington.** A \$230 million facility expansion
31776 was completed in 2012. It can accommodate six 110-car trains at any given time.
- 31777 • **Kalama Export Company & Pacifcor, LLC, Kalama, Washington.** A \$36 million facility
31778 upgrade was completed in 2011.
- 31779 • **TEMCO LLC, Kalama, Washington.** A \$100 million expansion was completed in 2015.
- 31780 • **United Grain, Vancouver, Washington.** A \$72 million facility upgrade completed in 2013.
- 31781 • **Columbia Grain, Portland, Oregon.** A \$44 million facility upgrade was conducted in 2011.

31782 The volume of barge freight moving between Portland, Oregon, and Pasco, Washington, is
31783 more than double the volume of freight moving on the lower Snake River, but both sections of
31784 that river have experienced declines in barge freight volumes, particularly in the past 10 years.
31785 Generally speaking, upriver freight movements are primarily serving to deliver inputs such as
31786 fuel, fertilizer, chemicals (agricultural industry), aggregates and steel (construction industry),

31787 whereas downriver barge movements have provided export gateways for products produced in
31788 the Northwest, primarily bulk grain (wheat) and forest products.

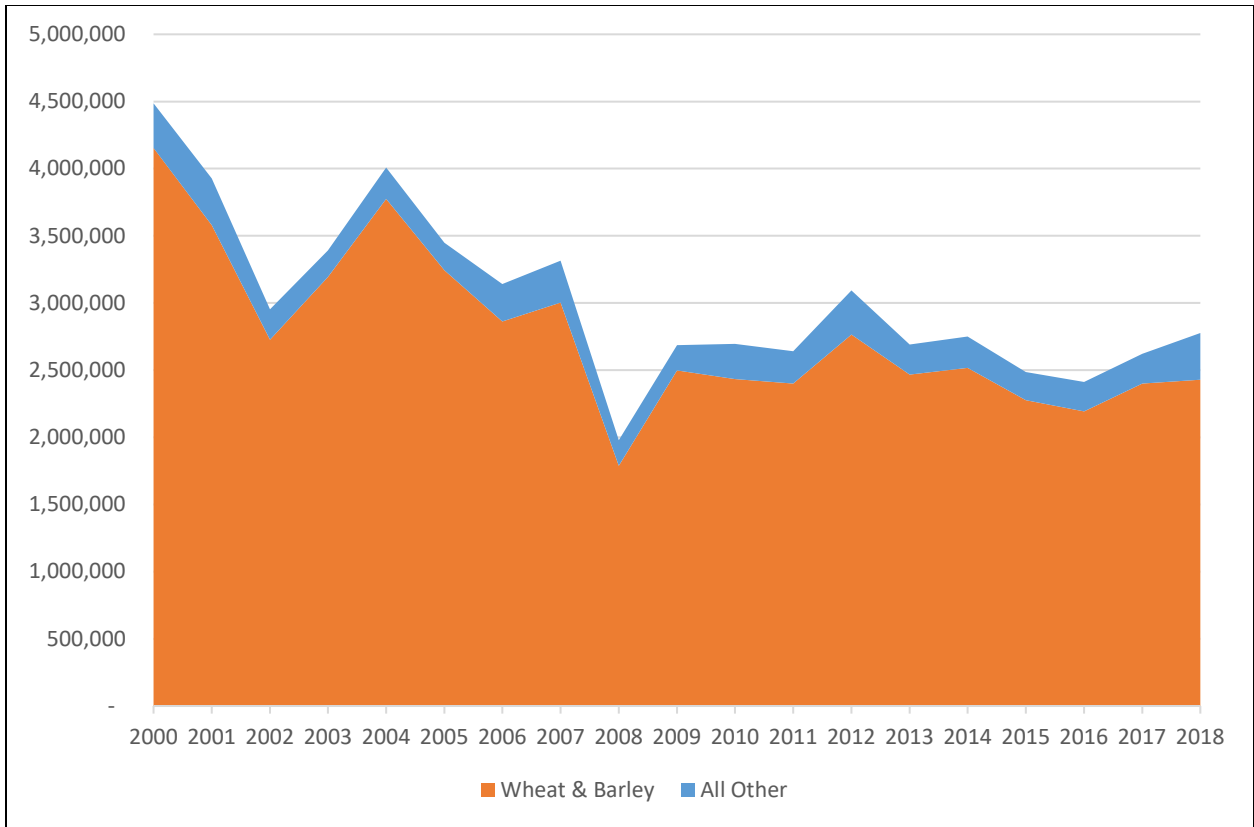
31789 Specific to the lower Snake River, total downriver tonnage decreased from 4.5 million tons in
31790 the year 2000 to 2.8 million tons in 2018 (Figure 3-198). However, within the past four years,
31791 total downriver shipments have somewhat rebounded. These increases are evident in Table 3-
31792 228, where the shipment of farm products has increased from 2.3 million in 2015 to 2.4 million
31793 in 2018. Upriver shipments, predominantly fuel, also decreased from 2.2 million in 2000 to 1.1
31794 million in 2018.

31795 On the Snake River, grain comprises the vast majority (more than 87 percent) of shipments on
31796 the lower Snake River. The total volume of these other commodities is relatively small;
31797 however, the system provides unique services associated with these commodities.

31798 • **Fuel and Other Petroleum Products.** Primarily an upriver movement that ends above
31799 McNary Dam near Pasco, fuel and other petroleum products travel via barge on the
31800 shallow-draft system. Fuel is the largest commodity shipped on the lower Snake River,
31801 comprising 91 percent of upbound tonnage in 2018, and 27 percent of the overall tonnage
31802 shipped on the river (Waterborne Commerce 2020). Until 2012, fuel was shipped further
31803 upriver to Wilma, but has not been shipped in recent years to that location (Tidewater
31804 Barge Lines 2020). As such, little fuel movements currently occur on the lower Snake River
31805 above Ice Harbor Dam.

31806 • **Wood Chips.** Wood chips travel both upriver and downriver in relatively small volumes in
31807 service of papermills that are located on or near the lower Snake River (approximately
31808 100,000 tons in 2018, representing 3 percent of all volume on the lower Snake River). In
31809 particular, a papermill in Lewiston receives regular shipments of wood chips.

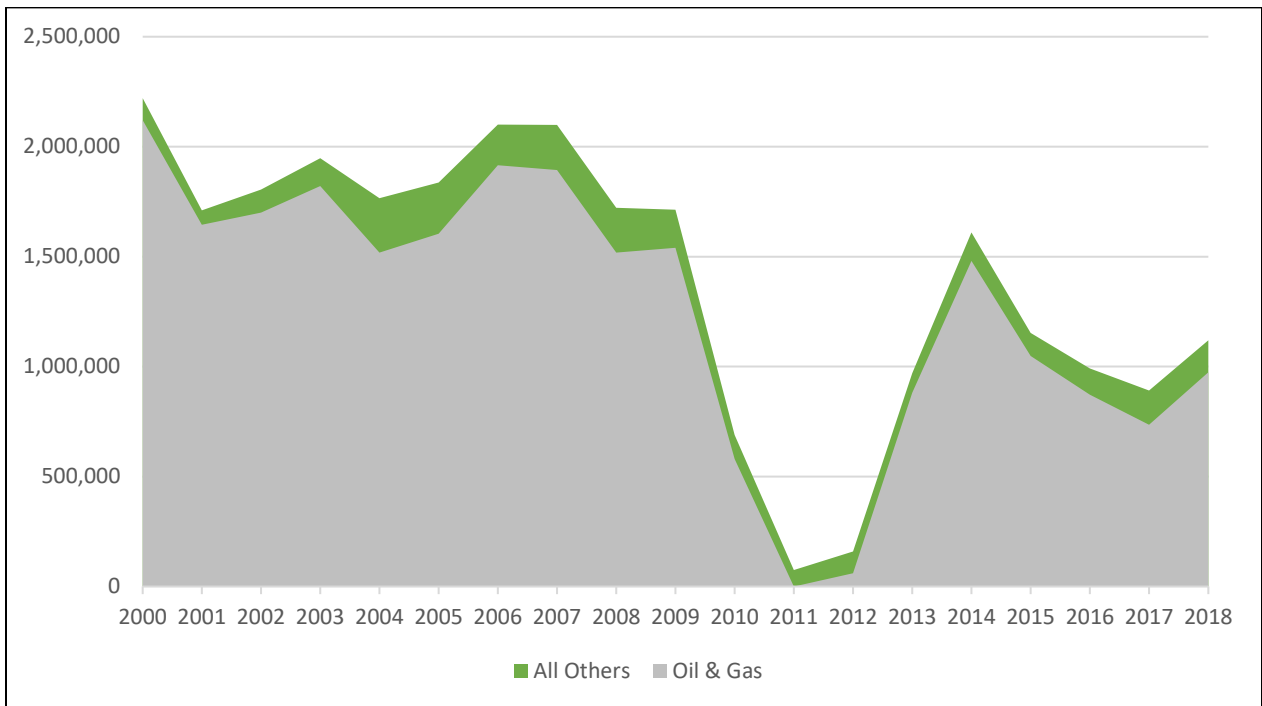
31810 • **Oversized Objects.** The Columbia-Snake River Navigation System (CSNS) provides a unique
31811 water route to transport oversized cargo into the interior of the United States. Cargo
31812 transported upriver to the Port of Lewiston can then be transported on U.S. Highway 12,
31813 which has no cargo height restrictions. U.S. Highway 12 has no overpasses and similarly
31814 there are routes in Montana that have no height restrictions. (Idaho Cooperating Agencies
31815 2020). While the system transports shipments of this type infrequently, it is a unique service
31816 that could not be replaced by road or rail alone.



31817

31818

Figure 3-198. Downbound Freight Shipments on the Snake River, 2000 to 2018, Tons



31819

31820

Figure 3-199. Upbound Freight Shipments on the Snake River, 2000 to 2018, Tons

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31821 **Table 3-228. Snake River Freight Volumes by Direction, 2015 to 2018, Thousand Tons**

Commodity	2015 (thousand tons)			2016 (thousand tons)			2017 (thousand tons)			2018 (thousand tons)		
	Up	Down	Total	Up	Down	Total	Up	Down	Total	Up	Down	Total
Coal	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum + Crude	1,049	17	1,067	872	6	879	736	7	736	975	5	979
Aggregates	0	0	0	0	0	0	0	0	0	0	0	0
Farm Products	0	2,276	2,276	20	2,194	2,213	63	2,401	2,464	0	2,428	2,428
Ores/Minerals	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	**1/	**	**	**	**	**	**	**	**	**	**	**
Iron/Steel	**	**	**	**	**	**	**	**	**	**	**	**
Combined Total**	47	58	105	58	113	171	72	137	209	66	264	330
Others	*2/	*	12	*	*	0	*	*	0	*	*	0
Forest & Paper Products	18	121	139	42	100	142	21	78	99	61	80	141
Total	1,114	2,472	3,599	992	2,413	3,405	892	2,623	3,508	1,102	2,777	3,878

31822 1/ **Chemicals, Iron/Steel are combined to allow for the display of the tonnage and not violate Federal Trade Secrets Act, 18 U.S.C. § 1905.

31823 2/ *Not displayed as there are less than three operators as required by Federal Trade Secrets Act, 18 U.S.C. § 1905.

31824 Note: Totals may not sum due to rounding.

31825 Source: Corps Waterborne Commerce Statistics (2020)

31826 **3.10.1.1 Area of Analysis**

31827 Because it is an important thoroughfare for goods shipping to international ports, MOs that
31828 affect shipping on the Columbia and lower Snake River system could have national implications.
31829 However, the majority of effects to the CRS navigation and transportation area of analysis
31830 would be experienced within the Columbia River Basin and, particularly, in Regions C and D.
31831 There are no anticipated effects to navigation and transportation in Canada under any
31832 alternative.

31833 The CSNS is the federally authorized navigation channel that stretches 470 miles and follows
31834 the navigable reaches of the lower Snake River beginning near Lewiston, Idaho and Clarkston,
31835 Washington, to its confluence with the Columbia River near Pasco, Washington, and then on
31836 the Columbia River to its confluence with the Pacific Ocean near Astoria, Oregon. The CSNS
31837 consists of three primary segments: (1) a 43-foot deep-draft segment between the Pacific
31838 Ocean and Portland, Oregon, and Vancouver, Washington (RM106) in Region D, (2) a 28-foot
31839 segment (maintained at 17 feet) of the Columbia River between Vancouver, Washington and
31840 The Dalles, Oregon in Region D, and (3) a 14-foot shallow-draft section of the Columbia River,
31841 which stretches from The Dalles to Pasco, Washington, in Region D, to the Snake River RM 140
31842 at Lewiston, Idaho, and Clarkston, Washington (Figure 3-200). The area of analysis for river ferry
31843 transportation includes Lake Roosevelt at the Grand Coulee project in Washington and the
31844 Westport Slough of the lower Columbia River. The Lake Roosevelt ferry transportation occurs
31845 within Region B, while the Westport Slough ferry transportation is within Region D. There are
31846 no proposed measures within the MOs that would potentially impact navigation or
31847 transportation within Region A compared to the No Action Alternative; therefore, Region A is
31848 not assessed further. The focus of the analysis includes Regions B, C, and D.



31849
 31850

Figure 3-200. Map of the Columbia-Snake Navigation System

31851 **3.10.2 Affected Environment**

31852 **3.10.2.1 Commercial Navigation and Transportation Systems¹**

31853 Commercial vessels are “used in transporting by water, either merchandise or passengers for
31854 compensation or hire, or in the course of business of the owner, lessee, or operator of the
31855 vessel.” (33 C.F.R. 207.800) As such, commercial navigation on the CSNS includes shipping,
31856 cruise lines, ferry services, as well as other vessels used for hire.

31857 **FEDERAL NAVIGATION SYSTEM**

31858 Between 50 to 60 million tons of cargo is transported through the CSNS each year (Corps
31859 Waterborne Commerce Statistics 2018). As an import/export gateway, the CSNS is vital to the
31860 regional economy. There are no west coast rail or highway routes that offer transport of cargo
31861 without height or weight restrictions into the interior of the United States comparable to the
31862 CSNS.

31863 In addition, the navigation system is used by the public for recreational boating, which links to
31864 the navigation and recreation missions and stewardship of the co-lead agencies. This section
31865 describes commercial navigation activities for deep-draft and shallow-draft reaches of the
31866 Federal Navigation Channel (FNC).

31867 **Deep-Draft Navigation Channel**

31868 A 43-foot draft navigation channel is maintained on the lowermost 106 miles of the Columbia
31869 River from Vancouver, Washington, to the Pacific Ocean. The Columbia River channel serves
31870 multiple deep-water ports as an integrated system along the lower 106 river miles. It is the
31871 primary pathway for the deep-draft channels of the CSNS; however, tributary streams and
31872 waterways such as the Cowlitz River, Lewis River, Willamette River, and Oregon Slough provide
31873 important access to the Columbia River and eventually the Pacific Ocean. In fact, much of the
31874 Port of Portland is on the Willamette River, which joins the Columbia River near RM 102. Access
31875 to the Pacific Ocean requires traversing a series of sandbars and shoals that occur at the mouth
31876 of the Columbia River, referred to as “the Bar.” A deep-draft channel through the Bar is
31877 maintained by annual dredging by the Corps, Portland District. Sediment movement, shoaling,
31878 and sand waves form commonly at other locations between the Bar and RM 106 (where the
31879 shallow-draft channel begins), especially in tight river bends and at the mouth of tributary
31880 streams, which requires dredging to maintain authorized channel depths.

31881 **Shallow-Draft Navigation Channel**

31882 From Vancouver, Washington (RM 106) to The Dalles Dam, the authorized channel is 27 feet
31883 deep and 300 feet wide; however, the channel is typically dredged only to 17 feet deep up to
31884 the Bonneville Dam and 14 feet deep between the Bonneville Dam and Dalles Dam, reflecting
31885 the maximum depth required by commercial traffic through this reach of the river. The

¹ This section discusses commercial navigation and transportation on the lower Snake and Columbia Rivers. Discussion of navigation and transportation on Lake Roosevelt is located in Section 3.10.2.3.

31886 remaining CSNS shallow-draft segment stretches from The Dalles to near Lewiston, Idaho on
31887 the Snake River (Snake RM 140) and is authorized for a 14-foot-deep and 250-foot-wide
31888 channel. Altogether, the inland portion of the CSNS covers the entire 470-mile-long water
31889 highway formed by the eight mainstem dams and lock facilities on the lower Columbia and
31890 Snake Rivers. The waterway provides inland waterborne navigation up and down the river from
31891 Lewiston, Idaho, to the Pacific Ocean. This system is used for commodity shipments from the
31892 Northwest to both domestic and international markets.

31893 **CURRENT AND HISTORICAL TONNAGE**

31894 Over the past 20 years, total cargo moved on the CSNS ranged between a recession-year low of
31895 46.4 million tons in 2009 to a high of 67.4 million tons in 2018 (Figure 3-201).

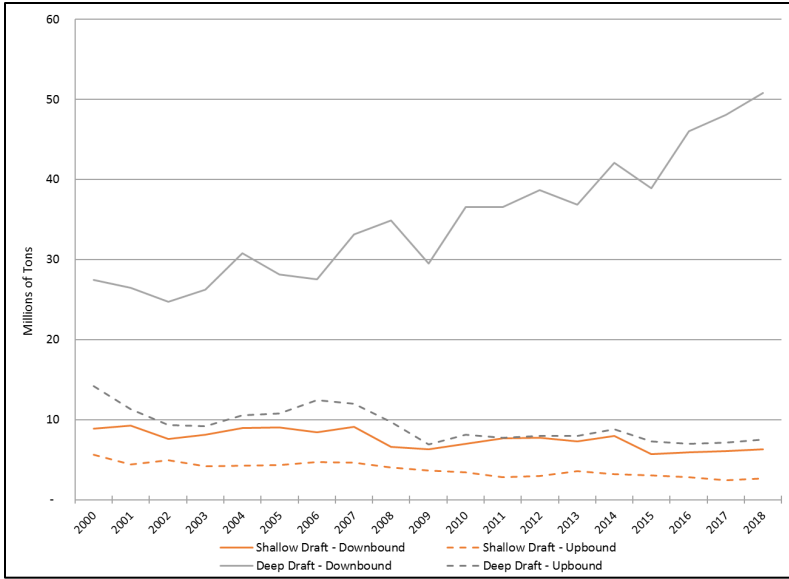
31896 **Table 3-229. Columbia-Snake Navigation System Tonnage, 2000 to 2018**

Year	Million Tons		
	Snake River	Columbia River	Total CSNS
2000	6.71	55.19	56.16
2001	5.64	50.35	51.41
2002	4.76	45.69	46.64
2003	5.34	47.16	47.75
2004	5.77	53.77	54.65
2005	5.29	51.49	52.29
2006	5.24	52.28	53.01
2007	5.42	58.15	58.87
2008	3.70	54.76	55.29
2009	4.40	45.96	46.37
2010	3.38	54.71	55.05
2011	2.72	54.23	54.75
2012	3.25	56.83	57.27
2013	3.66	55.33	55.70
2014	4.36	61.67	62.01
2015	3.64	54.72	55.00
2016	3.40	61.33	61.65
2017	3.51	63.39	63.68
2018	3.90	67.10	67.36
Average Annual Percent Change			
18-Year (2000 to 2018)	-1.68%	1.53%	1.46%
15-Year (2003 to 2018)	-0.72%	2.83%	2.77%
10-Year (2008 to 2018)	1.87%	2.57%	2.51%
5-Year (2013 to 2018)	2.07%	4.30%	4.24%

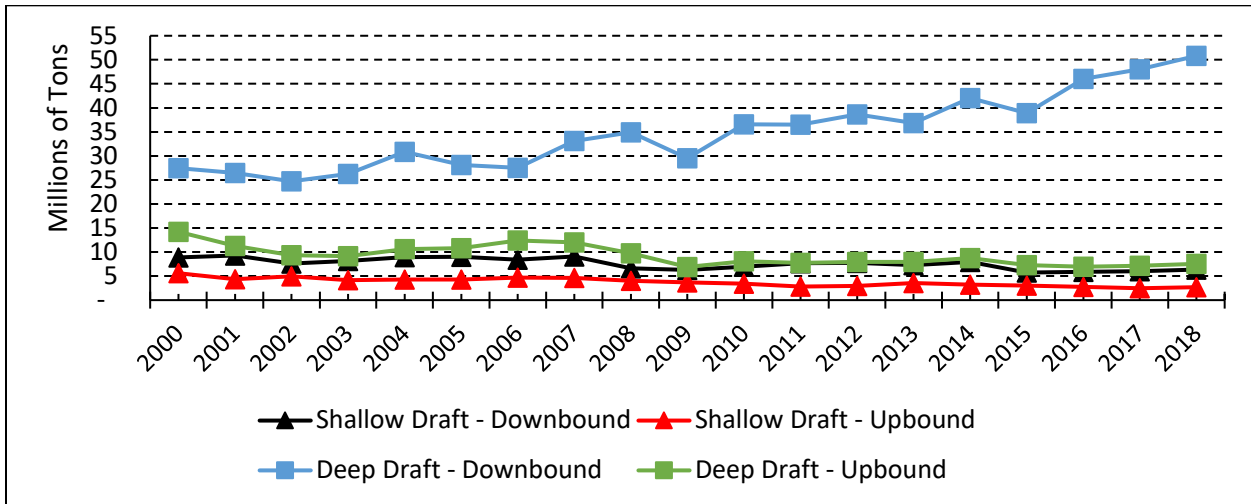
31897 Note: Values include traffic originating, terminating, or moving through these waterways. Values do not include
31898 traffic moving solely on tributaries to the Columbia and Snake Rivers.

31899 Source: Corps Waterborne Commerce Statistics (2020)

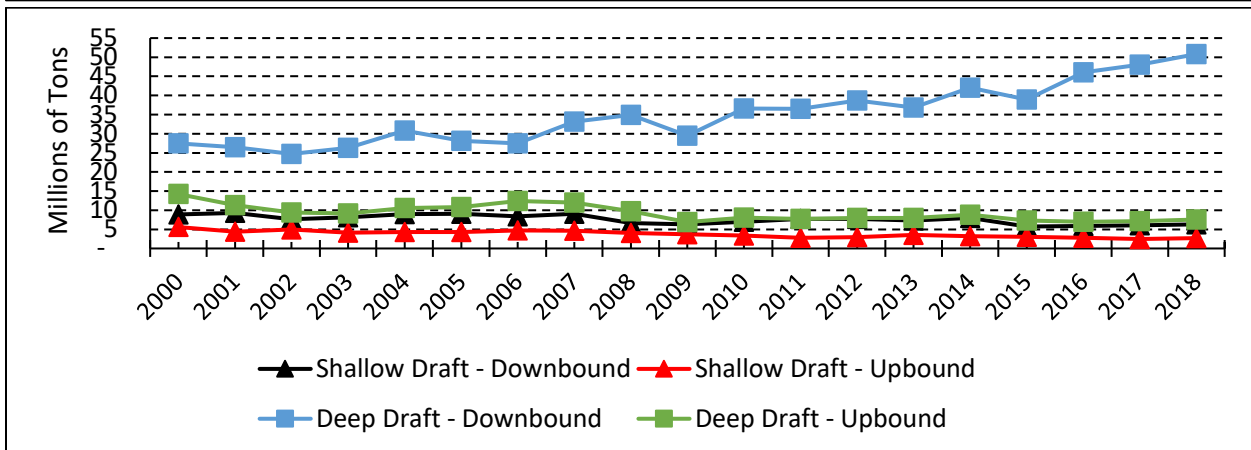
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Figure 3-201. CSNS Deep and Shallow Draft Freight Tonnage (2000 to 2018)

31904

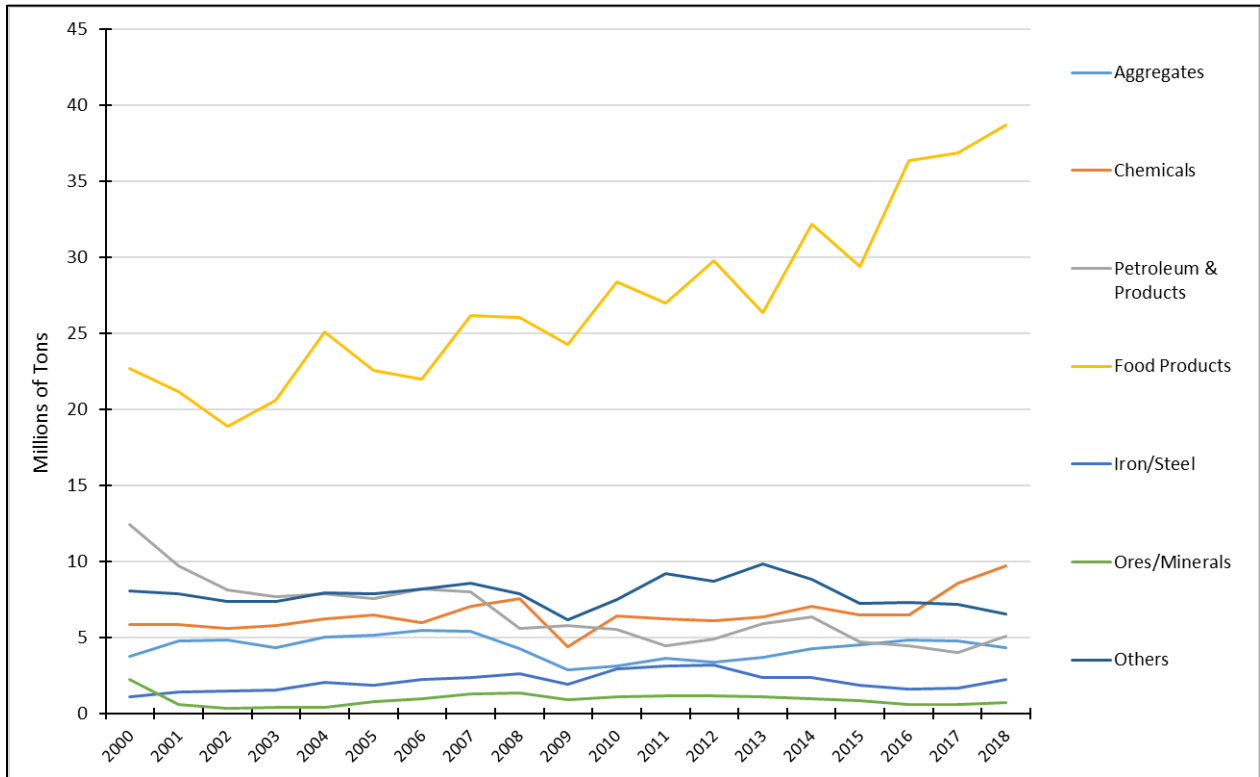
Note: Values include traffic originating, terminating, or moving through these waterways. Values do not include traffic moving solely on tributaries to the Columbia and Snake Rivers. Columbia River and Snake River shallow-draft tonnage are combined in this graph.

31906

31907

Source: Corps Waterborne Commerce Statistics (2020)

31908 Food products dominate the tonnage on the CSNS. Of the total commodities moving on the
 31909 CSNS, shown in Figure 3-202, food products account for over 56 percent of the average 61.9
 31910 million tons that moved on the CSNS between 2014 and 2018. Of these, wheat was the top
 31911 commodity with an average of 17.3 million tons (29.7 percent) moving on the CSNS between
 31912 2012 and 2016. Along with agricultural commodities, the most common movements on the
 31913 system between 2014 and 2018 included: chemicals (12.4 percent), “others” (12.0 percent),
 31914 petroleum and products (8.0 percent), aggregates (7.3 percent), iron and steel (3.1 percent),
 31915 and ores and minerals (1.2 percent). While most of the aggregates (i.e., pebbles, gravel, and
 31916 other raw materials) and wood chips (encapsulated within “others”) move intra-waterway,
 31917 potassium sodium carbonate and chloride fertilizers are bound for export.



31918 **Figure 3-202. Top 10 Commodities (Deep Draft and Shallow Draft) Moving on the CSNS, 2000**
 31919 **to 2018**

31921 Note: Rankings are based on average tonnage from 2012 to 2018.

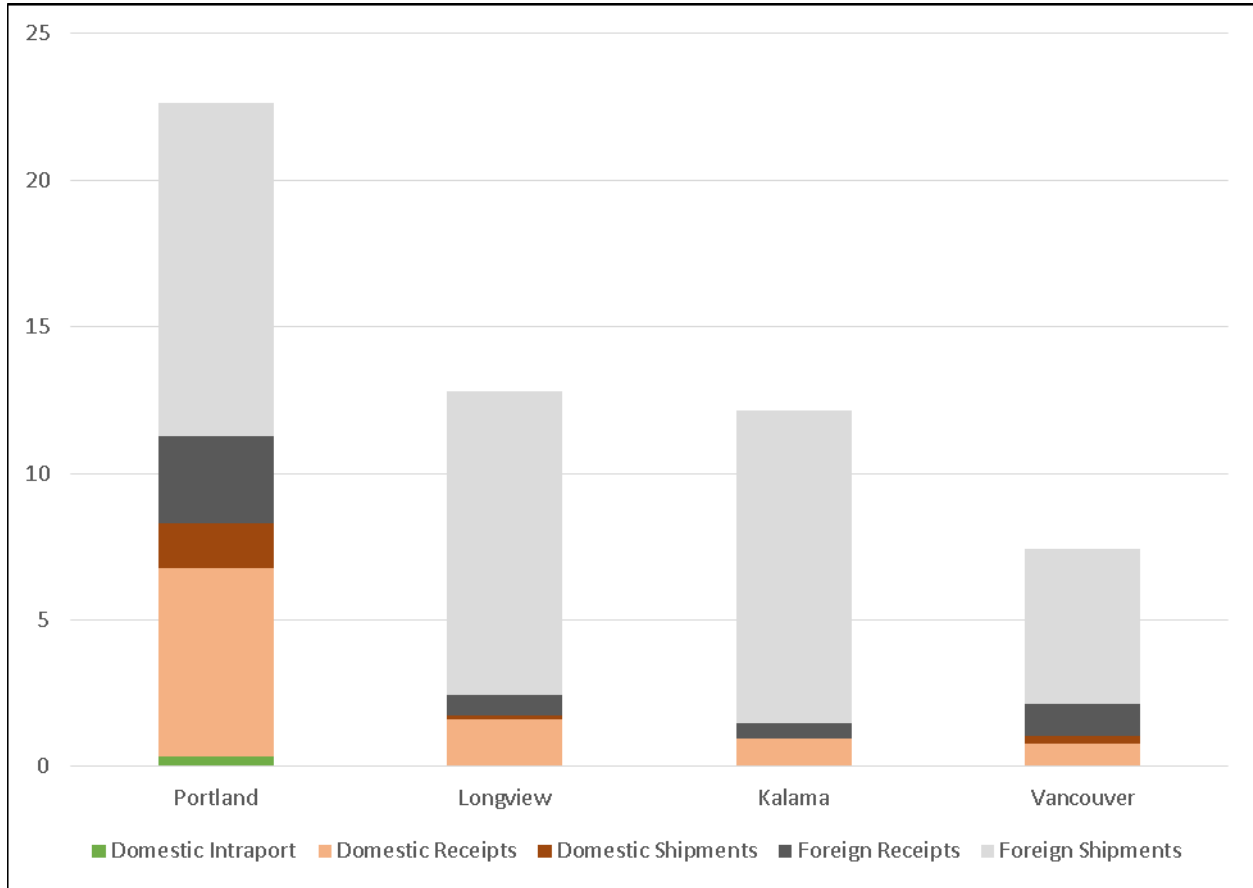
31922 Source: Corps Waterborne Commerce Statistics (2020)

31923 The next two subsections discuss the deep-draft and shallow-draft commerce on the CSNS.

31924 **Deep-Draft Navigation Channel**

31925 There are four major deep-water ports on the CSNS engaged in coastal and international trade:
 31926 Portland, Oregon; Kalama, Oregon; Longview, Washington; and Vancouver, Washington
 31927 (Figure 3-203). In 2016, these four ports ranked in the top 100 U.S. ports in tonnage terms.
 31928 Portland, Oregon, ranked 32nd; Kalama, Washington, ranked 41st; Longview, Washington,

31929 ranked 44th; and Vancouver, Washington, ranked 54th. The Ports of Astoria, Oregon, and St.
31930 Helens, Oregon, also handle significant amounts of cargo. Exports dominated the traffic in each
31931 of these ports. Only the Gulf-Intracoastal Waterway (with 8 ports), the Lower Mississippi (with
31932 5), and Puget Sound (with 3) had as many or more ports ranking in the top 50 as the CSNS.



31933 **Figure 3-203. Tonnage at Major Deepwater Ports on the CSNS (average 2012 to 2016, millions**
31934 **of tons)**
31935

31936 Note: Totals may not sum due to rounding.

31937 Source: Corps Waterborne Commerce Statistics (2018)

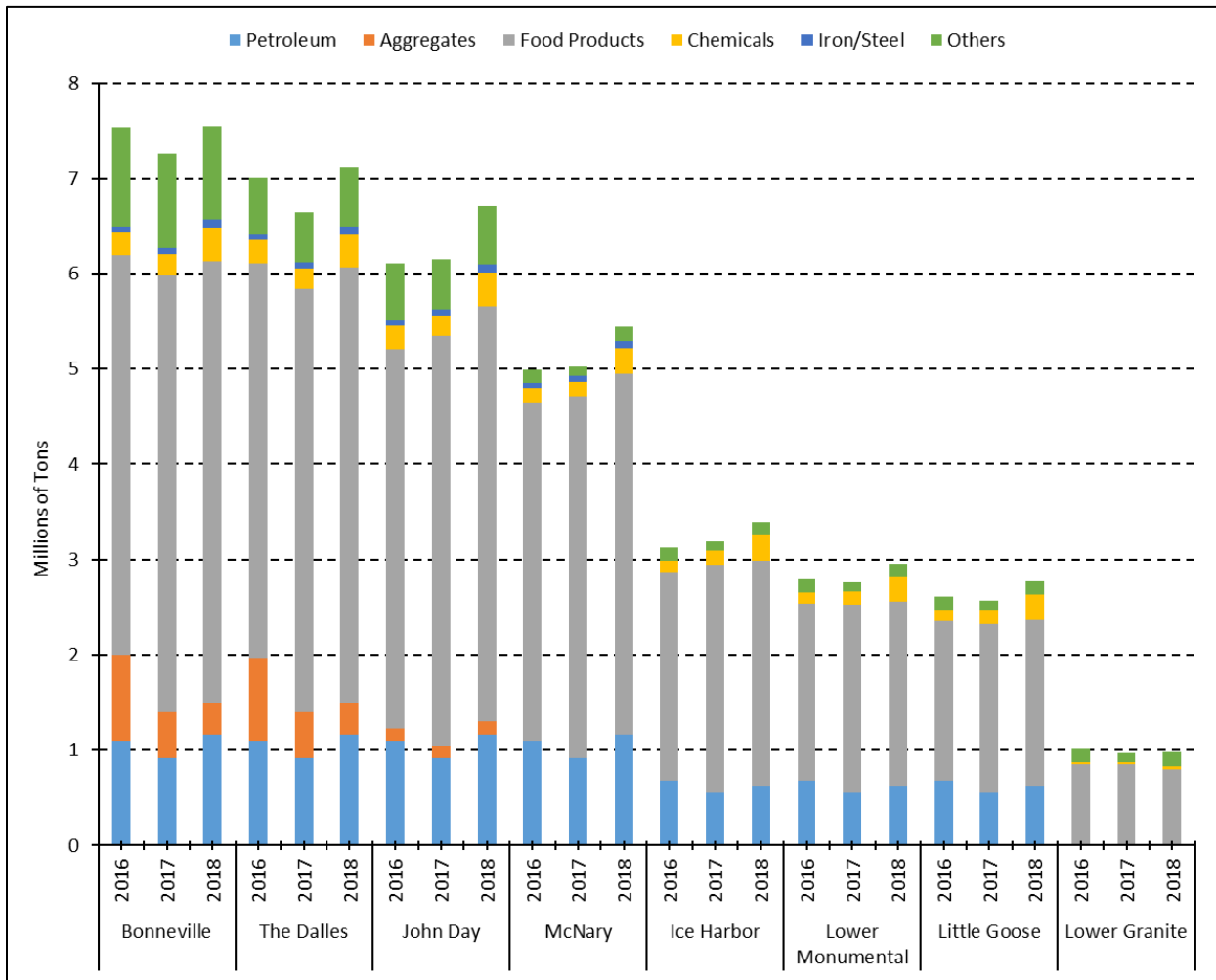
31938 Shallow-Draft Navigation Channel

31939 Shallow-draft (less than or equal to 14-foot draft) traffic moves on the CSNS along the roughly
31940 355 miles of waterway between Portland, Oregon, and the Clarkston, Washington–Lewiston,
31941 Idaho, area. In 2018, 8.6 million tons of traffic moved by shallow-draft barge on the CSNS, of
31942 which 3.9 million tons travelled on the Snake River.

31943 The majority (71 percent) of freight traffic on Snake River moves in the downstream direction
31944 (Figure 3-204). Though wheat tonnage decreased after 2014, wheat continues to account for
31945 greater than 87 percent of tonnage moving downstream on the Snake River. The main
31946 commodities moving upstream on the Snake River are petroleum products, particularly gas and
31947 oil.

31948 Traffic on the CSNS generally builds in volume moving from uppermost Lower Granite Dam to
 31949 Bonneville Dam on the lower Columbia River. As shown in Figure 3-203, the traffic on the Snake
 31950 River is approximately half of the levels on the Columbia River. The timber and agricultural-
 31951 based economies in the interior Northwest rely on the CSNS to reach international markets.
 31952 Figure 3-204 shows food products group which includes wheat moving the length of the river
 31953 through each lock in the CSNS. Logs and woodchips, classified under the “others” group, also
 31954 move the length of the river.

31955 also shows the upbound flows of petroleum products (fuel) and chemicals (fertilizers),
 31956 contained in the chemicals grouping, through the Columbia River locks. As discussed above, fuel
 31957 transport drops off above McNary Dam. Iron and steel, as well as waste materials and
 31958 manufactured equipment and machinery, contained in the “others” group, move primarily
 31959 through the lowermost three locks on the Columbia River reach of the CSNS. Note that in Figure
 31960 3-198, the McNary pool includes freight on the lower Columbia as well as the lower Snake
 31961 River.

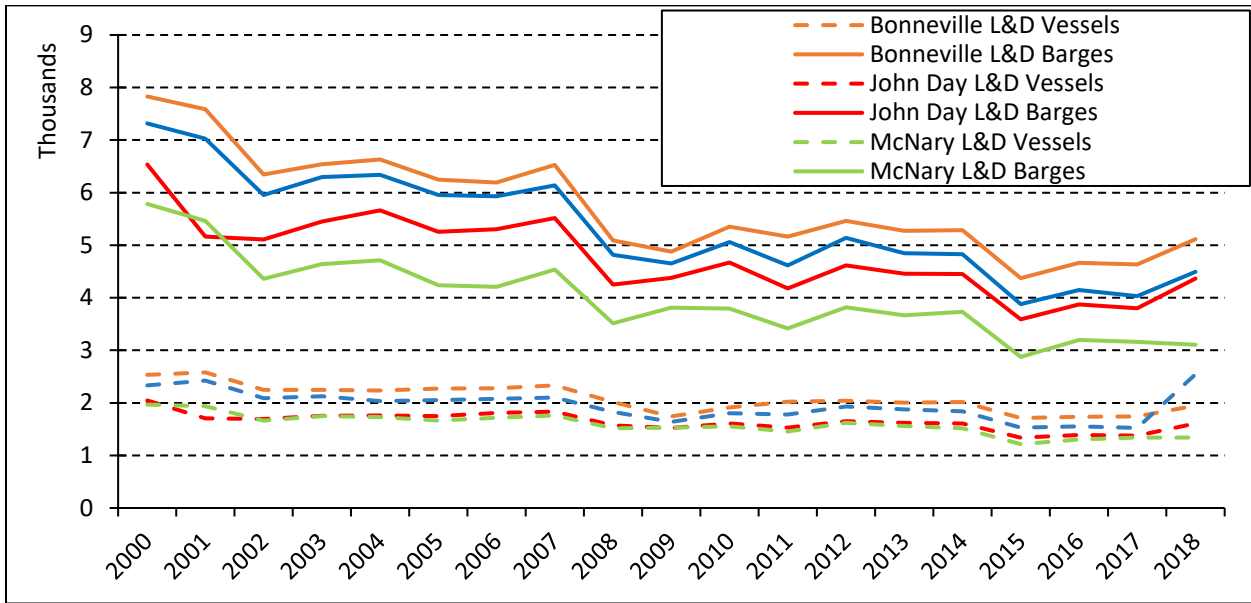


31962 **Figure 3-204. CSNS Lock Freight Volumes by Commodity Group, 2016 to 2018**
 31963

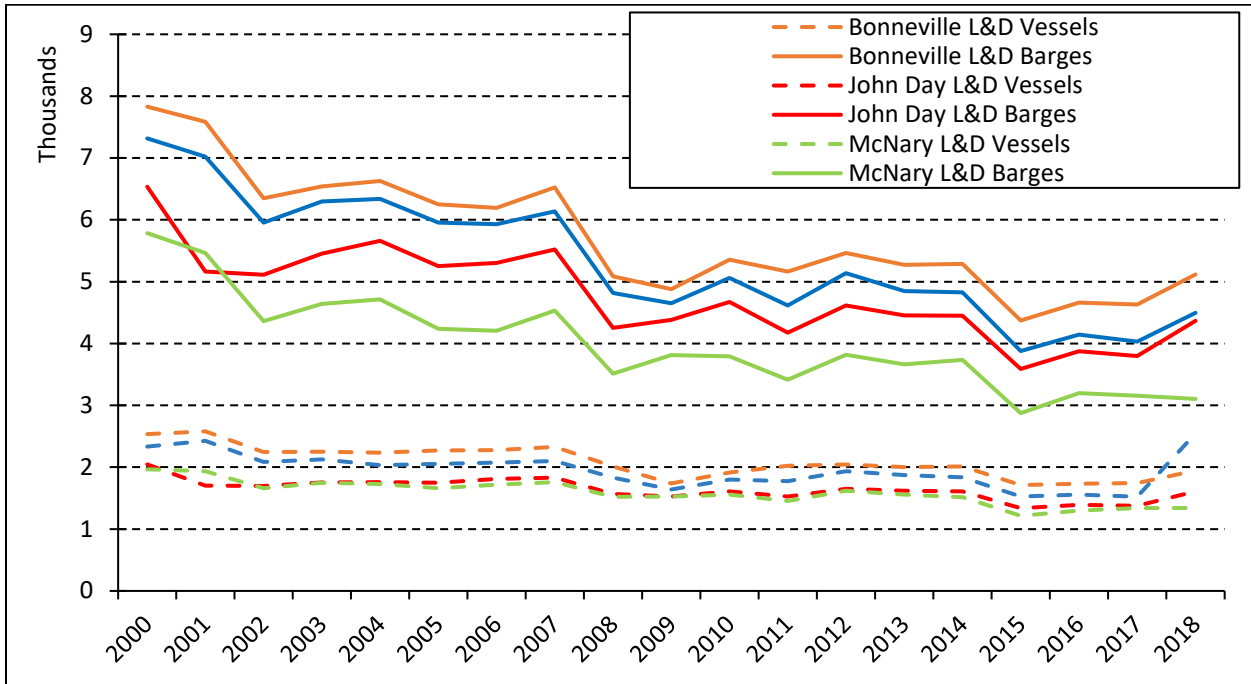
31964 Source: Corps Lock Performance Monitoring System (2020)

31965 **VESSEL INFORMATION**

31966 Since 2000, barge traffic through locks at the CSNS has trended downward, while vessel traffic
 31967 remained relatively stable. This suggests that the number of barges per vessel has declined over
 31968 the past 18 years (Figure 3-205 and Figure 3-206, Corps Waterborne Commerce Statistics
 31969 [2018]). Much of this is driven by changing export grain patterns for wheat in particular,
 31970 competition between North American ports and transportation modes, and ocean freight rates.



31971

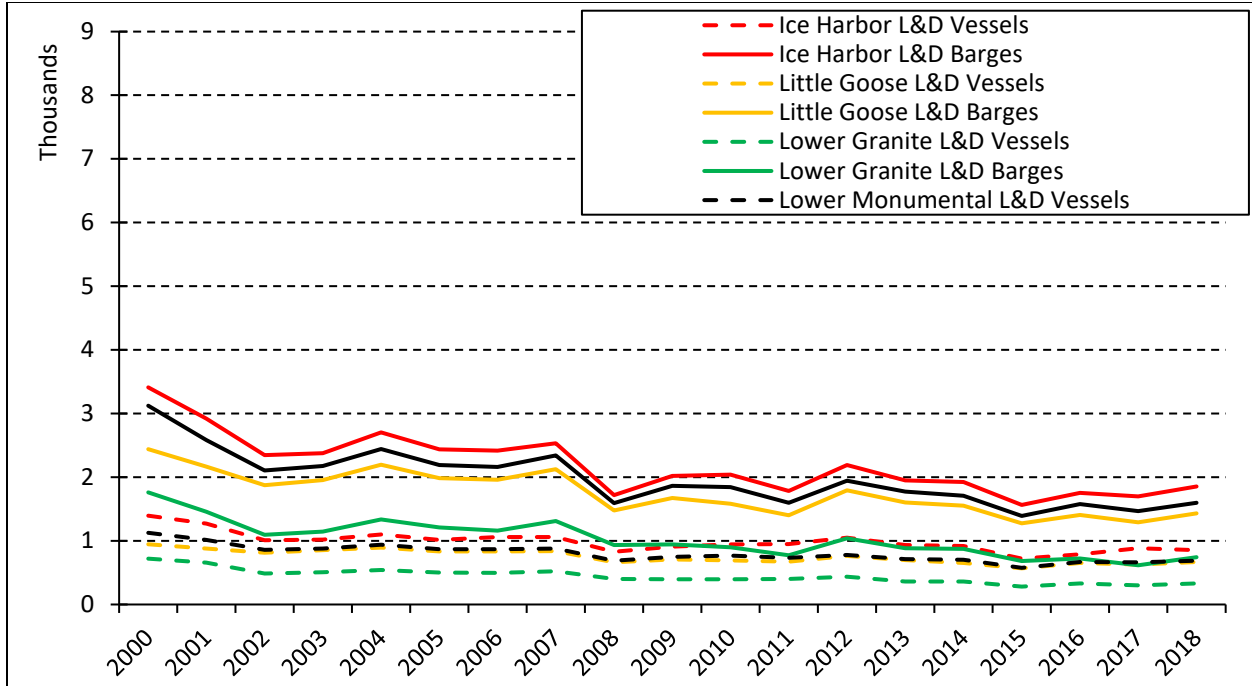


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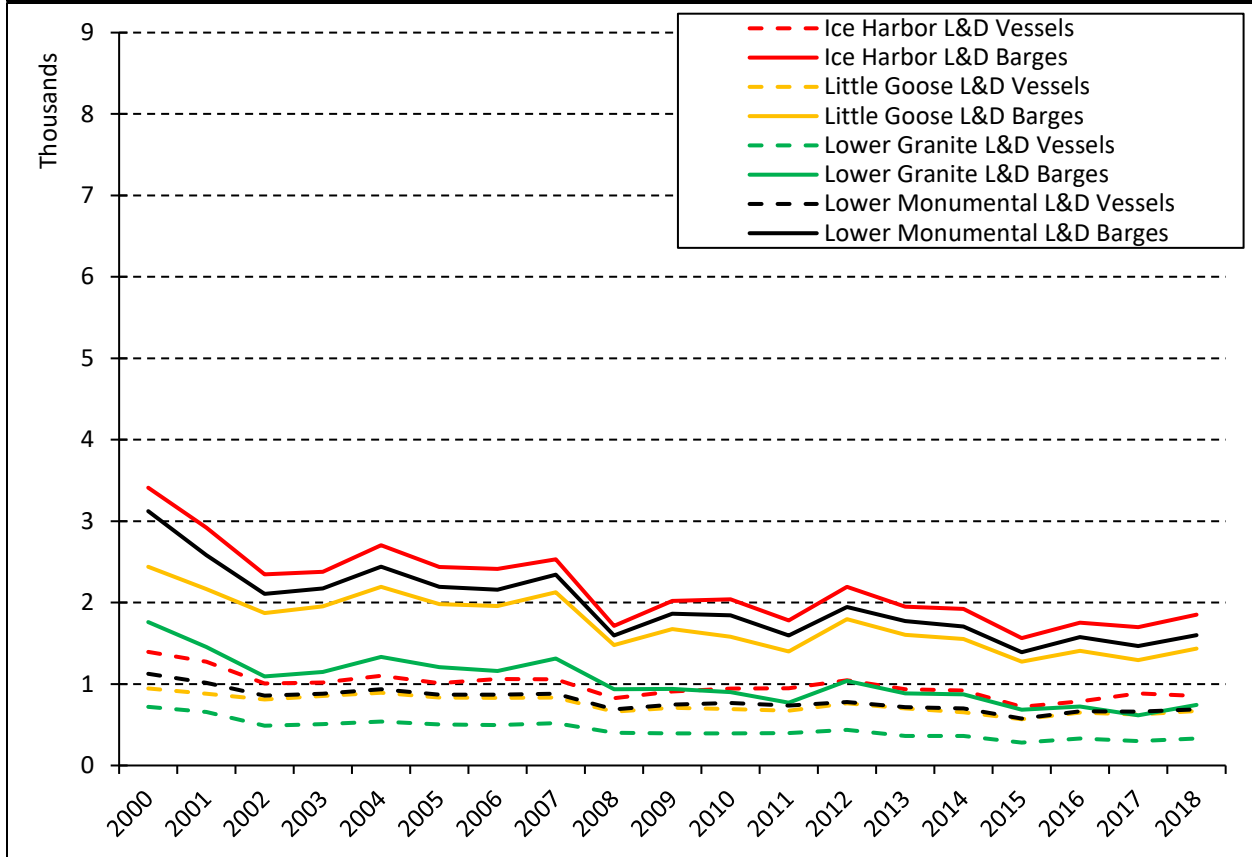
31973 **Figure 3-205. CSNS Columbia River Lock Traffic, Number of Vessels Trips and Barges (2000 to 2018)**

31974

31975 Source: Corps Lock Performance Monitoring System (2020)



31976



31977

31978

31979

Figure 3-206. CSNS Snake River Lock Traffic, Number of Vessels and Barges (2000 to 2018)

Source: Corps Lock Performance Monitoring System (2020)

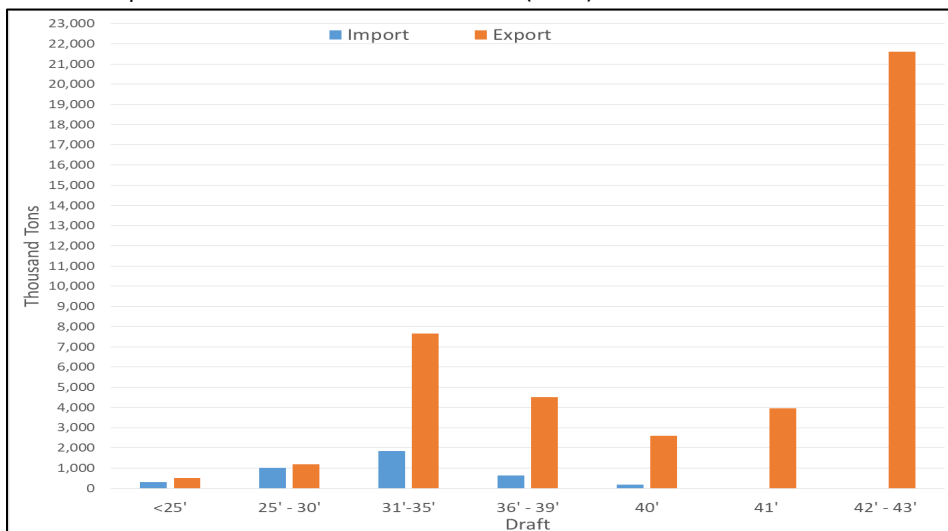
31980 **Deep-Draft Navigation Channel**

31981 Table 3-230. summarizes vessel calls, which are ship dockings at ports, on the CSNS by draft and
 31982 vessel type in 2016. Bulk carriers accounted for 75 percent of the deep-draft vessel calls on the
 31983 CSNS in 2016. Vessels with a draft of 39 feet or less account for 82 percent of all vessel calls,
 31984 and approximately 13 percent of the vessel calls in 2016 had drafts of 42 feet or 43 feet. While
 31985 the channel is 43 feet and vessels need 2 feet of under-keel clearance, the movements drafting
 31986 42 feet and 43 feet likely occurred when water levels were slightly higher. No vessels moved
 31987 with a draft over 43 feet (Corps Waterborne Commerce Statistics 2018). Bulk carriers account
 31988 for the great majority of deep-draft vessels maximizing the use of channel depth (Figure 3-
 31989 3-207).

31990 **Table 3-230. Deep-Draft Vessel Calls by Draft and Vessel Type, 2016**

Vessel/Commodity Class	Vessel Calls	% of Total Tons	Vessel Draft						
			<25'	25' - 30'	31'-35'	36' - 39'	40'	41'	42' - 43'
Tankers	149	5%	32	39	60	15	3	0	0
Container and RO/RO	20	1%	1	17	2	0	0	0	0
Cruise Ships	54	2%	16	38	–	–	–	–	–
Fishing Vessels	–	0%	–	–	–	–	–	–	–
General, Multi-deck Cargo	72	3%	25	12	18	12	3	2	–
Tank Barges	–	0%	0	0	0	0	0	0	0
Bulk Carriers	2,024	75%	863	199	337	147	58	68	352
Vehicle Carriers	394	15%	29	257	105	3	–	–	–
All Others	–	0%	0	0	0	0	0	0	0
Grand Total	2,713		966	562	522	177	64	70	352
Percent of Total		100%	36%	21%	19%	7%	2%	3%	13%

31991 Source: Corps Waterborne Commerce Statistics (2018)



31992 **Figure 3-207. CSNS Imports and Exports by Vessel Draft, 2016**
 31993 Source: Corps Waterborne Commerce Statistics (2018)

31994

31995 The largest deep-draft vessels are container ships, petroleum tankers, and tank barges. Both
 31996 tankers and tank barges can be nearly 1,000 feet long. Tank barges are pushed by oceangoing
 31997 tugs that notch into the barge. This trade is confined to the Pacific Coast, primarily out of
 31998 refineries in California and Washington. Container vessels moving on the CSNS can be nearly
 31999 1,000 feet long. The ocean trade, though, is dominated by bulk vessels in the Handysize and
 32000 Handymax class. These vessels are generally in 490 to 655 feet long, have onboard cranes, and
 32001 capacities from 15,000 to 60,000 tons (Corps Waterborne Commerce Statistics 2018). These
 32002 features make them ideal for serving Pacific Rim ports with limited draft and infrastructure.
 32003 Bulk carriers in these classes accounted for 75 percent of dry bulk carrier vessel calls on the
 32004 CSNS (Table 3-230.).

32005 Shallow-Draft Navigation Channel

32006 In 2016, dry cargo barges accounted for 60 percent of the barge fleet on the CSNS
 32007 (Table 3-231.). The preponderance of covered dry cargo barges reflects the importance of
 32008 wheat in the mix of commodities moving on the inland/shallow-draft system. Deck barges
 32009 (often used to move containerized cargo) account for another 21 percent of all non-self-
 32010 propelled vessels, followed by tank barges used to carry petroleum products and liquid
 32011 chemicals. Though not all barges are used in the canalized portion of the CSNS above Bonneville
 32012 Lock and Dam, all but 5 of the 172 barges in the 2016 fleet were capable of moving through the
 32013 86-foot-wide lock chambers. The largest barges were dominated by tank barges (17 of the 30
 32014 large barges). In the next largest category, the 251-foot to 300-foot length group, covered
 32015 hopper barges dominated and accounted for over 54 percent of all covered dry cargo barges.
 32016 Barges in the fleet do not necessarily move through the locks as many are used in the coastal
 32017 trade between California, Oregon, Washington, and Canadian Pacific coast ports.

32018 Table 3-231. Inland Non-Self-Propelled Vessel (Barge) Fleet

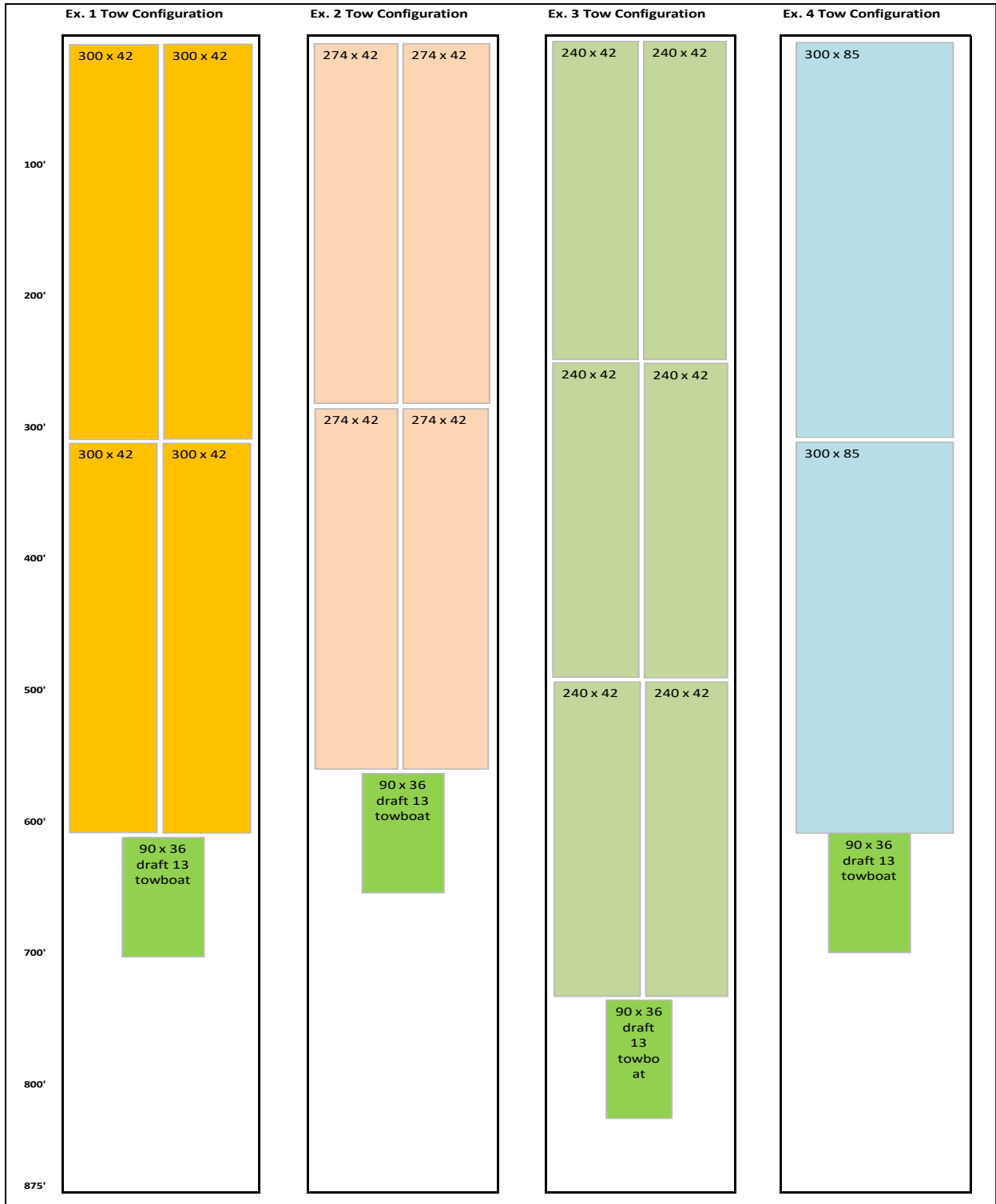
LENGTH (ft)	WIDTH (ft)	DRAFT (ft)	BARGE TYPES					TOTAL
			Deck	Tanker	Open Dry Cargo	Covered Dry Cargo	Other	
130-200	30-42	13-15	0	0	1	0	0	1
130-200	30-42	7-12	12	0	3	0	0	15
130-200	30-42	16-18	0	0	3	0	0	3
130-200	43-60	7-12	0	0	6	0	0	6
200-239	30-42	7-12	0	0	1	2	0	3
200-239	30-42	16-18	0	0	0	4	0	4
200-239	43-60	7-12	5	1	0	0	0	6
200-239	43-60	13-15	0	0	1	0	0	1
240-250	30-42	7-12	0	0	0	3	0	3
240-250	30-42	13-15	0	0	1	5	0	6
240-250	30-42	16-18	0	0	1	18	1	20
240-250	43-60	13-15	2	1	1	0	0	4
240-250	61-85	7-12	0	0	1	0	0	1
240-250	61-85	13-15	2	0	0	0	0	2

LENGTH (ft)	WIDTH (ft)	DRAFT (ft)	BARGE TYPES					TOTAL
			Deck	Tanker	Open Dry Cargo	Covered Dry Cargo	Other	
251-300	30-42	7-12	1	0	1	0	0	2
251-300	30-42	13-15	2	0	3	12	0	17
251-300	30-42	16-18	0	4	3	29	0	36
251-300	43-60	7-12	3	0	1	0	0	4
251-300	43-60	13-15	1	0	0	0	0	1
251-300	43-60	16-18	0	1	0	0	0	1
251-300	61-85	13-15	1	0	1	0	0	2
251-300	61-85	16-18	0	4	0	0	0	4
>300	61-85	13-15	1	2	0	0	1	4
>300	61-85	16-18	2	0	0	2	0	4
>300	61-85	>18	0	15	0	0	2	17
>300	>85	16-18	4	0	0	0	0	4
>300	>85	>18	0	0	0	0	1	1
TOTAL			36	28	28	75	5	172
PERCENTAGE			21%	16%	16%	44%	3%	

32019 Source: Corps Waterborne Commerce Statistics (2018)

32020 Figure 3-208 shows possible tow configurations for four of the more common barge types in
 32021 the system. As can be seen in the figure, most barge sizes in a four-barge tow configuration can
 32022 be comfortably accommodated in CSNS lock chambers. While the 240-foot x 42-foot barges
 32023 could be configured in four-barge tows, few barges of this size are available to vessel operators
 32024 on the CSNS. It should be noted that tows do not necessarily move in configurations using
 32025 barges of the same dimension.

32026 Traffic has held fairly steady between 2012 and 2018 at CSNS locks. Tonnages generally build
 32027 moving downstream, ranging from a 7-year average low of 1.1 million tons at Lower Granite
 32028 Dam to a high of 8.0 million tons at lowermost Bonneville Dam (Table 3-232.). In 2018, 1,948
 32029 tows pushing 5,118 barges moved traffic through Bonneville Dam, while 333 tows pushing 724
 32030 barges moved Lower Granite tonnage. Also in 2018, the average tow sizes for CSNS locks
 32031 ranged between 2.0 barges per tow at Lower Granite and 2.69 barges per tow at The Dalles
 32032 Dam. Depending upon the lock, barges used on the CSNS carried between 2,791 tons and 4,458
 32033 tons on average between 2012 and 2018. The average tons per tow ranged from 2,633 tons to
 32034 6,094 tons during this time period.



32035
 32036
 32037

Figure 3-208. Tow Configurations that Maximize Chamber Dimensions

Source: Corps Planning Center of Expertise for Inland Navigation (2018)

32038 **Table 3-232. Barge Fleet Trips at CSNS Locks**

Dam	Commercial Tows	Loaded Barges	Empty Barges	Total Barge Trips	Avg. Barges per Tow	Tons	Avg. Tons per Tow	Avg. Tons per Barge
BONNEVILLE								
2012	2,022	3,044	2,422	5,466	2.70	8,656,743	4,281	2,844
2013	1,973	2,933	2,338	5,271	2.67	8,663,888	4,391	2,954
2014	2,014	2,887	2,399	5,286	2.62	8,881,373	4,410	3,076
2015	1,729	2,425	1,948	4,373	2.53	7,474,639	4,323	3,082
2016	1,762	2,603	2,060	4,663	2.65	7,538,894	4,279	2,896
2017	1,744	2,547	2,080	4,632	2.66	7,259,045	4,162	2,850
2018	1,948	2,844	2,274	5,118	2.63	7,539,575	3,870	2,651
THE DALLES								
2012	1,881	2,899	2,241	5,140	2.73	8,000,438	4,253	2,760
2013	1,843	2,723	2,126	4,849	2.63	7,975,050	4,327	2,929
2014	1,774	2,654	2,172	4,826	2.72	8,014,302	4,518	3,020
2015	1,493	2,172	1,707	3,879	2.60	6,922,001	4,636	3,187
2016	1,633	2,341	1,810	4,151	2.54	7,008,752	4,292	2,994
2017	1,523	2,236	1,794	4,030	2.65	6,641,853	4,361	2,970
2018	1,674	2,546	1,950	4,496	2.69	7,113,488	4,249	2,794
JOHN DAY								
2012	1,607	2,623	1,992	4,615	2.87	7,180,542	4,468	2,738
2013	1,536	2,499	1,958	4,457	2.90	7,062,087	4,598	2,826
2014	1,537	2,475	1,975	4,450	2.90	7,259,500	4,723	2,933
2015	1,266	1,996	1,593	3,589	2.83	6,114,768	4,830	3,064
2016	1,333	2,189	1,686	3,875	2.91	6,110,356	4,584	2,791
2017	1,523	1,379	2,084	1,714	1.13	6,147,415	4,036	4,458
2018	1,674	1,608	2,431	1,934	1.16	6,711,332	4,009	4,174
M McNARY								
2012	1,549	2,025	1,794	3,819	2.47	5,787,329	3,736	2,858
2013	1,460	1,914	1,752	3,666	2.51	5,761,352	3,946	3,010
2014	1,438	1,940	1,795	3,735	2.60	6,013,630	4,182	3,100
2015	1,144	1,473	1,402	2,875	2.51	5,025,262	4,393	3,412
2016	1,278	1,676	1,521	3,197	2.50	4,990,305	3,905	2,978
2017	1,338	1,610	1,548	3,158	2.36	5,026,911	3,757	3,122
2018	1,341	1,567	1,539	3,106	2.32	5,447,145	4,062	3,476
ICE HARBOR								
2012	1,142	1,183	1,010	2,193	1.92	3,053,786	2,674	2,581
2013	1,022	1,035	914	1,949	1.91	2,677,653	2,620	2,587
2014	1,034	1,013	910	1,923	1.86	2,725,772	2,636	2,691
2015	705	804	760	1,564	2.22	3,354,718	4,758	4,173
2016	780	912	841	1,753	2.25	3,127,310	4,009	3,429
2017	885	859	841	1,700	1.92	3,188,671	3,603	3,712
2018	853	949	903	1,852	2.17	3,390,904	3,975	3,573

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Dam	Commercial Tows	Loaded Barges	Empty Barges	Total Barge Trips	Avg. Barges per Tow	Tons	Avg. Tons per Tow	Avg. Tons per Barge
LOWER MONUMENTAL								
2012	710	1,059	886	1,945	2.74	2,672,201	3,764	2,523
2013	597	947	825	1,772	2.97	2,358,881	3,951	2,491
2014	619	902	806	1,708	2.76	2,261,442	3,653	2,507
2015	488	713	678	1,391	2.85	2,974,049	6,094	4,171
2016	601	813	765	1,578	2.63	2,789,537	4,641	3,431
2017	663	740	725	1,465	2.21	2,763,354	4,168	3,734
2018	687	825	775	1,578	2.30	2,957,543	4,305	3,585
LITTLE GOOSE								
2012	645	985	811	1,796	2.78	2,483,072	3,850	2,521
2013	577	860	744	1,604	2.78	2,183,437	3,784	2,539
2014	548	828	725	1,553	2.83	2,252,702	4,111	2,721
2015	469	658	617	1,275	2.72	2,842,717	6,061	4,320
2016	553	723	686	1,409	2.55	2,612,795	4,725	3,614
2017	625	641	652	1,293	2.07	2,568,278	4,109	4,007
2018	670	723	711	1,434	2.14	2,769,293	4,133	3,830
LOWER GRANITE								
2012	473	595	442	1,037	2.19	1,403,643	2,968	2,359
2013	391	500	384	884	2.26	1,204,565	3,081	2,409
2014	429	487	386	873	2.03	1,331,651	3,104	2,734
2015	305	358	327	685	2.25	1,049,660	3,442	2,932
2016	352	383	341	724	2.06	1,008,614	2,865	2,633
2017	301	314	302	616	2.05	967,796	3,215	3,082
2018	333	389	353	724	2	975,736	2,930	2,508

32039 Sources: Corps Waterborne Commerce Statistics (2020); Corps Lock Performance Monitoring System (2020)

32040 **RAIL AND HIGHWAY TRANSPORTATION**

32041 Railroads and highways provide alternative modes of commodity transport within the Columbia
 32042 River Basin. The recent decline in downriver barge freight on the
 32043 Snake River, primarily in wheat exports, has coincided with investments in shuttle rail facilities
 32044 in the Palouse region of Eastern Washington. Since 2002, four shuttle grain (rail) facilities have
 32045 been built in Eastern Washington, including:

- 32046 • Templin Terminal, Ritzville, Washington (2002)
- 32047 • McCoy Grain Terminal, Rosalia, Washington (2013)
- 32048 • Highline Grain, Four Lakes, Washington (2015)
- 32049 • Northwest Grain Growers, Endicott, Washington (2019)

32050 Trucks are also used for commodity transport, particularly for the movement of petroleum and
 32051 chemical products to inland destinations. Trucks are also used in conjunction with other modes
 32052 of transportation. For example, a significant portion of wheat and barley is harvested in eastern

32053 Washington and transported by truck to Lower Snake River ports. At these ports, wheat and
32054 barley shipments are transferred to barge and transported down river. The highway network
32055 serving the study area includes Federal, state, and county highways. The majority of the links in
32056 the network serve low traffic volumes.

32057 **DREDGING OPERATIONS**

32058 The Corps maintains the congressionally authorized depths of the Federal navigation channel
32059 throughout the Columbia River system. The ports and ship operators that use the CSNS depend
32060 upon the availability of the authorized depths to provide uninterrupted transit of fully loaded
32061 vessels. Dredging operations occur on a regular basis to maintain the deep-draft navigation
32062 channel while dredging is less frequent on the shallow-draft channel on the lower Columbia and
32063 lower Snake Rivers. Additional details are provided by navigation channel type below.

32064 **Deep-Draft Navigation Channel**

32065 The deep-draft system exists from the mouth of the Columbia River at RM 0, to the Portland,
32066 Oregon-Vancouver, WA area at RM 106. The dredging of the lower Columbia River, what is now
32067 the deep-draft channel, began in 1878, when a 20-foot channel depth was authorized by
32068 Congress. Over the years, the authorized channel depth and width has been increased by
32069 Congress multiple times. In 1892 a 25-foot channel was authorized and in 1912, Congress
32070 authorized a 30-foot channel and designated that the channel should be 300 feet wide. In 1930,
32071 Congress authorized a 35-foot channel. In 1962 Congress authorized the deepening and
32072 widening of the channel to a condition similar to current day – the authorized channel became
32073 600 feet wide and 40 feet deep. And in 1999, Congress authorized the current deep-draft
32074 channel depth of 43 feet.

32075 In order to maintain the current 600-foot width and 43-foot depth of the Columbia River deep-
32076 draft navigation channel, extensive dredging of the channel is required. The amount of
32077 sediment that accumulates in the channel is affected by the speed of the river flow. Generally,
32078 the faster the river flows (measured in cfs), the more sediment will build up in the navigation
32079 channel. Dredging of the deep-draft section of the Columbia River is typically completed by one
32080 of three Corps vessels, and in some instances, contracted dredges. On average, 6 to 7 MCY
32081 (million cubic yards) of sediment is dredged annually to maintain the Columbia deep-draft
32082 navigation channel.

32083 **Shallow-Draft Navigation Channel**

32084 The shallow-draft portion of the Columbia and Snake Rivers extends from the Vancouver, WA at
32085 Columbia River RM 106 upstream to Lewiston, Idaho, at Snake River RM 143. The portion of the
32086 river from about RM 106 on the Columbia to The Dalles Dam is authorized to 27 feet deep and
32087 300 feet wide but is maintained to 17 feet of depth up to Bonneville Dam and 14 feet of depth
32088 between Bonneville Dam and The Dalles Dam. The portion of navigable waterway above The
32089 Dalles Dam to Lewiston is congressionally authorized to be 14 feet deep and 250 feet wide.

32090 Maintenance dredging on the lower Snake River for navigation purposes began in the 1970s,
32091 and channel maintenance continues in accordance with the Corps' 2014 Programmatic
32092 Sediment Management Plan (PSMP). The PSMP provides a framework to evaluate and
32093 implement long-term potential sediment management and reduction measures to address
32094 problem sediment areas. The PSMP also provides for interim management measures and
32095 dredging and dredged-material management for areas where sediment has accumulated to a
32096 point where it is interfering with safe navigation. The most recent maintenance dredging and
32097 disposal action under the PSMP occurred in early 2015, based on the identification of a need to
32098 address sediment accumulation that was interfering with commercial navigation. Prior to
32099 adoption of the PSMP, the last dredging operation occurred in the winter of 2005-2006. The
32100 approximate 9-year gap in dredging operations is longer than the historic average, as the Corps
32101 has historically addressed problem sediment that interfered with project purposes areas every
32102 3 to 5 years. The longer period between the most recent maintenance actions was due
32103 primarily to a 2005 Settlement Agreement intended to resolve litigation over the Corps draft
32104 2002 Dredged Material Management Plan, which led to study and preparation of the PSMP.
32105 Based on studies associated with the PSMP and historical data, it is anticipated that the
32106 majority of problem sediment management activities will continue to occur within Lower
32107 Granite Reservoir at the confluence of the Snake and Clearwater Rivers.

32108 The 2005–2006 dredging activities removed approximately 336,000 cubic yards of sediment
32109 from the lower Snake River. The dredging performed under the 2015-2016 PSMP study
32110 removed 372,603 cubic yards of sediment. The main areas of sediment buildup occur at the
32111 confluence of the Snake and Clearwater Rivers near the Port of Clarkston, Washington, as well
32112 as at the Port of Lewiston at the confluence with the Clearwater River.

32113 ***3.10.2.2 Cruise Line Operations and Other Recreational Use of Navigation Channel and Locks***

32114 As of 2019, seven river cruise ships have dedicated Columbia-Snake River itineraries (Macuk
32115 2019). Approximately 18,000 passengers cruise along the river annually (Pacific Northwest
32116 Waterways Association 2017). Passenger ridership primarily occurs between April and
32117 November on lower Snake River cruise lines, and ridership has been growing in recent years.
32118 One cruise company reported that it more than doubled its passenger capacity on the CSNS in
32119 2016 when it added a new vessel (Cruise Industry News 2015); it then introduced another large
32120 river cruise ship in 2018 (Macuk 2019). In 2018, the Columbia River outsold the Mississippi River
32121 for the first time, and all six operating cruise ships reported being sold out between May to
32122 October (Macuk 2019). One cruise company more than doubled its passenger capacity on the
32123 Columbia-Snake in 2016 with a new ship (Cruise Industry News 2015), and then introduced
32124 another large river cruise ship in 2018 (Macuk 2019).

32125 Commercial cruise ships on the Columbia and Snake Rivers typically cruise between Clarkston,
32126 Washington, and Astoria, Oregon, on the Pacific coast, with embarkation or disembarkation in
32127 Portland, depending on which direction the ship is traveling. Most of the cruises are seven
32128 nights with the option of a pre- or post-stay in Portland. Along the way, the ships traverse eight
32129 locks (Uzelac 2018). A standard itinerary might would involve stopping at (1) Portland, Oregon;

32130 (2) Astoria, Oregon; (3) Mount St. Helens, Washington; (4) Stevenson, Washington; (5) The
32131 Dalles, Oregon; (6) Pendleton, Oregon, or Richland, Washington; and (7) Clarkston, Washington
32132 (ACL 2019). Clarkston, Washington, is located in Region C and the other six ports of call are
32133 located in Region D.

32134 On the industry side, cruise boat operators make a range of payments. They pay fees associated
32135 with the use of a port, and purchase food and other perishable items. Operators also purchase
32136 necessary goods and services for the vessels, such as fuel, waste disposal, line handling, and
32137 local pilots. Cruise lines may also hire local entertainers and tour guides as part of their services
32138 (Macuk 2019).

32139 The navigation channel and locks of the CSNS are used not only by large, commercial vessels,
32140 but also by smaller, recreational vessels (Figure 3-209). When recreational boaters wish to
32141 move upstream or downstream past one of the CRS dams, their vessel must first be determined
32142 suitable to lock through. To maintain safety as a priority, non-motorized vessels and those
32143 deemed not suitable for safe passage through the navigation locks are advised to be
32144 transported by land around the dams. For those recreational vessels suitable for lockage, the
32145 Corps' Portland District and Walla Walla District post instructions for safe lockage on their
32146 respective websites. The CSNS navigation locks offer a seasonal recreation-priority lock use,
32147 which runs typically from mid-May through mid-September each year. Even during recreation-
32148 priority season, vessel operators must request permission to lock through from the lock
32149 operator to allow for confirmation that the conditions are safe. For the remainder of the
32150 calendar year, recreational vessel lockage is made available during daylight hours only and after
32151 requesting permission ahead of arrival. The CSNS navigation locks are closed to all river traffic
32152 annually in March for approximately 2 weeks to conduct routine maintenance.



32153

32154

32155

Figure 3-209. Vessels in Navigation Lock

Source: Corps' PAO Office, Portland District 2019

32156 **3.10.2.3 Ferry Transportation**

32157 The Confederated Tribes of the Colville Reservation (CTCR) operates a free ferry, the Columbia
32158 Princess, between Inchelium and Gifford, Washington, on Lake Roosevelt on the eastern side of
32159 the reservation. In 2018, a total of 150,000 passengers rode the Inchelium-Gifford ferry, which
32160 is equivalent to approximately 410 passengers per day on average (CTCR 2019). The 2018 data
32161 suggests that most of the travel is by individual passengers, many of whom traveled in some of
32162 the 87,000 cars on trips across the river, as well as buses, trucks, and bicycles. Travel occurs
32163 throughout the year, but peaks in summer months. People who live in rural towns near
32164 Inchelium on the Colville Reservation describe the ferry as a “lifeline” (KHQ 2014). The ferry is
32165 important to commuters, schoolchildren, emergency services, tourists, and the tribe as a whole
32166 (CTCR 2019; FHWA 2017; KHQ 2014). When the ferry does not operate, schoolchildren living in
32167 the areas must be bussed on a 70-mile detour to the nearest bridge and people who need
32168 medical attention face an hour and a half drive instead of a free, six-minute ferry ride to reach
32169 the community health care clinic (KHQ 2014). The Tribe also reports that the ferry is important
32170 for transport of gas, food, and supplies (CTCR 2019). Although the Tribe has requested that a
32171 bridge be built to replace the ferry, this project has not been planned. The ferry closes in above-
32172 average water conditions (typically during the spring) when water levels do not permit the ferry
32173 to operate. The docks only allow the ferry to operate when reservoir elevations are higher than
32174 1,229 feet above sea level (NAVD29). In 2018, the ferry was shut down 20 days during April
32175 and May because the water level was too low (CTCR 2019). When the water level falls below
32176 this level, the ferry has to halt operations until water levels rise (CTCR 2019).

32177 The Washington Department of Transportation operates the Keller Ferry, which also operates
32178 on Lake Roosevelt. Approximately 60,000 vehicles travel on the Keller Ferry each year. The free
32179 ferry operates 7 days a week, 18 hours a day, and can operate normally with lake levels as low
32180 as 1,208 feet. During normal lake elevation of 1,290 feet above sea level to approximately 1,248
32181 feet, ferry service is "on-demand" to avoid unnecessary empty runs.

32182 Wahkiakum Ferry has operated near Westport Slough on the lower Columbia River in
32183 Washington State since 1925. It operates 365 days a year, making at least 18 runs a day. The
32184 ferry is run by the Wahkiakum County Public Works Department and offers single-trip and
32185 frequent traveler rates to tourists and commuters (Wahkiakum Chamber of Commerce 2019).

32186 **3.10.3 Environmental Consequences**

32187 The MOs include actions with the potential to affect reservoir elevations, river flows and stages,
32188 sedimentation patterns, as well as system configuration (e.g., under MO3, due to breaching of
32189 four lower Snake River dams, the Snake River shallow-draft reach is assumed to be inoperable).
32190 These physical changes in reservoir and river conditions could potentially affect commercial
32191 navigation activities, commercial ferry operations and/or commercial cruise ship operations, as
32192 well as access to the navigation channel from existing port and/or dock facilities. Depending on
32193 the effects to the navigation channel and adjacent facilities, additional maintenance or
32194 dredging may be required. Changes to the CSNS will influence the cost of transporting goods in
32195 the region and may affect the accessibility of the system for use by ferries and cruise ships.

32196 Changes in transportation costs and accessibility will affect social welfare values and regional
32197 spending patterns, and may also result in other social effects. This section describes effects to
32198 commercial navigation and transportation from changes in river flows, depths, and
32199 configuration that may result from the MOs.

32200 **3.10.3.1 Methodology**

32201 The analysis assesses effects of the MOs associated with changes to commercial navigation
32202 activities, commercial cruise line operations, ferry operations, and related transportation
32203 system (e.g., road and/or railway) effects as compared to the No Action Alternative. Effects to
32204 dredging activities are also described. The analysis begins by establishing the baseline
32205 conditions that would be anticipated under the No Action Alternative. For each activity, the
32206 analysis then assesses potential effects of MOs on social welfare (i.e., national economic
32207 development), regional economic spending patterns, as well as other social effects:

32208 Social welfare effects are changes to the economic value of the national output of goods and
32209 services. The economic value includes producer surplus gained from commercial navigation
32210 activities, as well as the value, or the improved well-being, gleaned by tourists and
32211 recreationists associated with cruise line visits (referred to by economists as consumer surplus
32212 or net economic value). For this analysis, effects to commercial navigation activities are
32213 measured in terms of changes in transportation costs. The model itself does not address
32214 transitional costs associated with short-term infrastructure investments that may be required.
32215 Transitional costs are the short-term, one-time infrastructure investment costs that would be
32216 required to add capacity to remaining alternate transportation modes. Specifically for this
32217 analysis, transitional costs would include investments in road, highway, adding and/or
32218 upgrading rail (both short line and Class 1), as well as adding storage capacity at shuttle rail
32219 facilities and grain elevators.

32220 The following are included as part of the regional economic effects discussion.

- 32221 • Regional economic effects are changes in the distribution of regional economic activity (e.g.,
32222 income and jobs), which is affected by changes in expenditures. Because the pattern of
32223 freight transportation may change in the Columbia River Basin under different alternatives,
32224 so too might the distribution of regional economic activity. The regional economic effects
32225 are distinct from the national social welfare effects in that they relate to effects mainly to
32226 the localized or regional economic area, instead of the nation as a whole. For MOs that
32227 involve modal changes, transitional costs may be associated with infrastructure
32228 investments, particularly highways, bridges, and rails that may be required and are also
32229 reported under regional economic effects. Over the long term, price increases on the
32230 primarily private rail system should adjust to cover these costs, but may not in the short
32231 term. Highway maintenance cost increases may be covered by public investments.
32232 Additional regional effects may be associated with changes in cruise line or ferry operations
32233 and are reported as regional economic effects.

32234 • Other social effects are community and social effects that are relevant to various MOs, but
32235 are not addressed under social welfare or regional economic effects. Additionally, air
32236 emissions could increase or decrease with different transportation modes in place. For MOs
32237 where commercial navigation freight is shifted to other transportation modes, like trucks,
32238 effects to air emissions would increase. Other effects that are not dependent on modal
32239 changes may include impacts to community well-being, identity, and cohesion. Section 3.17,
32240 *Indian Trust Assets, Tribal Perspectives, and Tribal Interests*, provides additional information
32241 about ongoing effects and unique effects of MOs on tribal ceremonial activities, subsistence
32242 activities, and other cultural practices.

32243 Impacts to Canadian transportation systems are not anticipated under any MOs and are not
32244 addressed further in this analysis.

32245 **SOCIAL WELFARE EFFECTS**

32246 **Commercial Navigation and Transportation Systems**

32247 Businesses that transport bulk commodities in the Interior Northwest often pay lower
32248 transportation costs than parties transporting commodities via land transportation (GAO 2011).
32249 These inland navigation benefits are often referred to as “transportation rate savings.”
32250 Transportation rate savings are the difference between the cost of transporting commodities
32251 over the waterway and the next least cost alternative mode of transportation, typically rail or
32252 roadway. These transportation rate savings provide an estimate of changes in social welfare
32253 associated with an alternative.

32254 This analysis uses two models to evaluate the effects of changes to social welfare. The Snake
32255 Columbia Economic Navigation Tool (SCENT) is a model that calculates changes in
32256 transportation costs attributable to changes in flows and/or navigation channel depths on the
32257 commercially navigable portions of the Columbia and Snake Rivers. For MO3, where navigation
32258 is expected to be eliminated for a portion of the CSNS, the Transportation Optimization Model
32259 (TOM) is used in addition to the SCENT. The TOM is used to assess the flow of shipments under
32260 a dam breach scenario where navigation on the lower Snake River is eliminated.

32261 Summary information is provided about the models in the sections that follow; more detailed
32262 information about the models, data inputs, and results is provided in Appendix L, *Navigation*.

32263 **Modeling Changes to River Flow and Timing**

32264 The SCENT model is used to estimate changes in transportation costs for alternatives that may
32265 affect flow and/or navigation channel depth. The model also accounts for changes in the timing
32266 of operations. The SCENT model is used to evaluate effects for MO1, MO2, and MO4. It is also
32267 used to evaluate effects for the Columbia River deep-draft and shallow-draft portions of MO3.
32268 The SCENT requires the following inputs:

32269 • Daily flows in cfs and daily water surface elevations, which have been developed as part of
32270 the H&H analysis as an output from the ResSim model. The ResSim model sampled 80 years

- 32271 of historical river data to create 5,000 years of daily flows and water surface elevations,
32272 which were fed into the SCENT model.
- 32273 • Data on the number and types of waterway vessels, including, barges and towboats using
32274 the CSNS provide by the Corps Lock Performance Monitoring System (LPMS) for 2016.²
 - 32275 • Data on the costs for operating waterway vessels provided by the Corps' Institute for Water
32276 Resources Waterborne Commerce Statistical Center (2016 costs updated to 2019 dollars).
 - 32277 • Origin, destination, commodity volumes, and type for all movements (i.e., river origin to
32278 river destination) traveling on the CSNS for a given year. For this analysis, 2016 movements
32279 are used. The CSNS characteristics in 2016 were chosen because the SCENT model requires
32280 a list of movements to estimate the effects to navigation. The list of movements is
32281 generated by combining several sources of data including the Corps' Waterborne
32282 Commerce Statistics (WCS), LPMS, Port Import and Exporting Reporting Service (PIERS), and
32283 other sources. All datasets were available for 2016.³
 - 32284 • Survey responses indicating movement decisions of operators to various flow, stage, depth,
32285 and velocity thresholds (documented in 2016). The responses of industry to this survey are
32286 reflected in the modeling assumptions described in this section.
- 32287 The SCENT output is an estimate of navigation transportation costs under each alternative. A
32288 comparison in transportation costs between the No Action Alternative and the MOs determines
32289 the impact to waterway transportation costs under each MO. The SCENT calculates draft
32290 restrictions based on modeled water surface elevations and shoaling depths (between 37 and
32291 42 feet).
- 32292 SCENT results are calculated separately for the shallow-draft and deep-draft portions of the
32293 CSNS. Shallow draft is broken down into three subcategories, for a total of four industry
32294 segments:
- 32295 • **Deep Draft** pertains to the Columbia River below Bonneville Dam
 - 32296 • **Snake Shallow** refers to movements that originate and terminate on the lower Snake River⁴
 - 32297 • **Columbia Shallow** refers to movements that originate and terminate on the Columbia River,
32298 above Portland, Oregon
 - 32299 • **Columbia-Snake Shallow** refers to movements that originate on the lower Snake and
32300 terminate on the Columbia, or vice versa

² Note that in December 2016, a planned 4-month extended maintenance outage on the Columbia and Snake Rivers occurred. As such, the system was down for maintenance and extra 3 weeks for this outage in this year (2 weeks in March, 3 weeks in December).

³ Since the SCENT datasets are from 2016, it was necessary to adjust the price level from 2016 to 2019. To accomplish this, the producer price index for inland water freight transportation, from the St. Louis Federal Reserve Bank, was used. All figures in this section are presented in 2019 dollars.

⁴ For this analysis, there were no movements in 2016 (the year the SCENT datasets are from) that originated and terminated solely on the Snake River. Therefore, the Snake Shallow category is not included within the alternative results tables.

32301 River flows can affect the operating costs for navigators on the river. Low river flows as well as
 32302 particularly high river flows result in increased costs for commercial navigation activities when
 32303 compared with normal flow conditions. Low flow and high flow conditions may result in a need
 32304 for changes in tow configuration and/or changes in loading or the number of barge trips
 32305 required. For deep-draft vessels, channel depth changes that cause draft restrictions affect
 32306 operating costs by requiring light loading or other adjustments to account for limitations in
 32307 channel depth. Based on the survey responses described above, normal, low, high, very high,
 32308 and too high flow conditions for navigation operations on the CSNS were identified. These flow
 32309 rate categories and associated flow ranges are presented in Table 3-233.. The SCENT model is
 32310 used to estimate the additional costs for commercial navigation activities of operations in other
 32311 than normal flow conditions in these years.

32312 **Table 3-233. Flow Range Categories for Commercial Navigation on the Columbia-Snake**
 32313 **Navigation System (kcfs)**

Flow Category	Columbia Shallow/Deep Draft	Snake Shallow
Normal	80–299	15–80
Low	0–79	0–14
High	300–399	80–120
Very High	400–499	120–180
Too High	>500	180–1,000

32314 In order to help account for normal variability, a standard deviation⁵ was calculated to
 32315 determine the range of costs that would be anticipated to fall within one standard deviation of
 32316 the deep-draft and shallow-draft flow categories and the deep-draft restrictions under the No
 32317 Action Alternative. For each of the MOs, the standard deviation range was then used to
 32318 highlight those changes in costs that would be outside of one standard deviation of the current
 32319 (No Action) condition.

32320 ***Modeling Effects of Changes in Channel Accessibility***

32321 The TOM is used to assess the movements of shipments under a dam breach scenario where
 32322 navigation on the lower Snake River would be eliminated. Under MO3, it is assumed that a
 32323 portion of the navigation channel would be inoperable, therefore affected shippers would be
 32324 required to use a different transportation mode or combination of modes (e.g., shuttle rail,
 32325 connector rail, roadway, Columbia River shallow- and/or deep-draft channel). Therefore, the
 32326 TOM is used to evaluate the flow of goods from origin points, through intermediate
 32327 destinations, and ultimately to final destinations.

32328 The TOM is a constrained optimization model designed to simulate the transportation choices
 32329 facing shippers that use the CSNS. The TOM focuses on goods that are shipped in the region
 32330 surrounding the lower Snake River shallow-draft portion of the CSNS, recognizing that the lower
 32331 Snake River shallow-draft channel is predominately used to move grain (wheat) downriver and

⁵ Standard deviation is a number used to tell how measurements for a group are spread out from the average (mean) or expected value.

32332 fuel upriver. There are other commodities moved in smaller volumes, but wheat comprises
32333 more than 87 percent of the tonnage moved on the lower Snake River. Therefore, the TOM is
32334 designed to capture the choices faced by shippers moving grain to market.

32335 Information gathered through a survey of shippers conducted as part of this EIS was used as a
32336 framework for the model to evaluate how goods would move through the system if the lower
32337 Snake River navigation channel is made inoperable.⁶ Model parameters include the capacities
32338 of each facility, shipping alternatives, cost of each shipping alternative, choices made under the
32339 No Action Alternative, and choices that would be made if the navigation channel was
32340 unavailable. The model is sensitive to price assumptions, which affect the modal choices. For
32341 the social welfare analysis, the relevant output of the TOM is the change in cost of grain
32342 movements affected by lower Snake River navigation being eliminated.⁷ As discussed above,
32343 grain (wheat and barley) comprises approximately 87 percent of downriver-bound shipments
32344 on the lower Snake River.

32345 ***Modeling Effects to Dredging and Maintenance Activities***

32346 Changes to sedimentation patterns in the CSNS system have the potential to impede
32347 commercial navigation activities and/or may result in increased need for dredging activities in
32348 some areas. Increased dredging activities would increase dredging costs. While qualitative
32349 analysis was conducted to describe the impacts to dredging activities from MO1, MO2, and
32350 MO4, the *Breach Snake Embankments* measure require a quantitative estimate.

32351 Potential effects to dredging activities were evaluated for each alternative based upon the River
32352 Mechanics results (see River Mechanics Section 3.3.3), along with input from District
32353 operations and cost engineering experts. Potential changes to dredging costs were estimated
32354 using the following steps:

- 32355 • Step 1: Estimate the potential amount of additional sediment from an operational or
32356 structural *measure(s)*. For example, the *Breach Snake Embankments* measure would lead to
32357 an increase in sediment within the McNary Pool for several years after breaching (see
32358 Section 3.10.3.5, *Dredging Operations*).
- 32359 • Step 2: Based upon the capacity of the channel, flows, and other information, identify the
32360 likely areas within lower Snake and lower Columbia River for increased sedimentation.
- 32361 • Step 3: Estimate likely dredging volumes and schedule for key areas such as the Federal
32362 navigation channel, as well as related public and private navigation-related facilities.

⁶ The survey response rate was 48 percent. Additional meetings and information gathering efforts were undertaken to supplement information gathered by the survey in order to fill remaining information gaps.

⁷ Fuel was included in the shipper survey, but there were not enough responses from those shippers to include it in modeled results.

- 32363 • Step 4: Develop a per-cost estimate for dredging to estimate the total cost for dredging
32364 activities, depending upon the dredging location.

32365 By comparing the estimated dredging cost to the No Action Alternative, the analysis developed
32366 an estimate for the impact in dredging cost by MO.

32367 **Commercial Cruise Line Operations**

32368 Under MO1, MO2, and MO4, potential effects to commercial cruise lines are estimated using
32369 estimates of changes in the number of low and high flow days generated with the SCENT
32370 model. Under MO3, commercial cruise line access to the lower Snake River would be eliminated
32371 and the analysis estimates the number of cruise line trips that would be precluded. Substitution
32372 of trips is assumed to be not possible within the region.

32373 **Commercial Ferry Operations**

32374 This analysis focuses on the Inchelium-Gifford Ferry on Lake Roosevelt in Region B because
32375 elevation changes from the MOs may affect its operations in some years. Two additional ferries,
32376 the Keller Ferry on Lake Roosevelt in Region B, and the Wahkiakum Ferry, located near
32377 Westport, Oregon, in Region D, are not anticipated to be affected by elevation changes or
32378 changes to flow conditions under any alternative and are not addressed in further detail.

32379 Under each alternative, anticipated daily reservoir water surface elevations in Lake Roosevelt
32380 are evaluated at ferry port locations to determine whether ferries could operate. The analysis
32381 uses H&H data for each alternative for dry, wet, and average water years at Lake Roosevelt
32382 (Grand Coulee Dam forebay elevation) and compares it to established minimum operating
32383 elevations for each ferry using daily elevation forecasts.⁸ This comparison results in an estimate
32384 of the number of days annually that water levels would be at or above the minimum usable
32385 elevation for ferry operations. The minimum usable elevation for ferry operations of 1,229 feet
32386 NAVGD29 was identified through communications with ferry operators.

32387 **REGIONAL ECONOMIC EFFECTS**

32388 **Commercial Navigation and Transportation Systems**

32389 The regional economic effects analysis of commercial navigation evaluates how potential
32390 changes to navigation and transportation costs (and associated activities) would impact
32391 regional economies. The analysis describes the port facilities in the CSNS, and how these ports
32392 would be affected by changes in the flows and/or navigation channel depths (or both) on the
32393 commercially navigable portions of the Columbia and lower Snake Rivers. It also considers

⁸ To determine these categories, water years are grouped into "wet," "average or typical," or "dry" years based on the May 1 April-August water supply. Then the median elevation is taken for each day within the group. Water years are categorized with respect to the forecasted runoff volume percentile: dry years represent the driest 20 percent, average years represent forecasts between 20 and 80 percent, and wet years represent greater than 80 percent. Grand Coulee use The Dalles forecast volumes.

32394 effects to port services, including navigation freight companies, that could result if navigation is
32395 eliminated under MO3. This evaluates potential regional economic effects associated with
32396 increased costs to the agriculture industry; increased demands for infrastructure, including
32397 highways, rail lines, and grain elevators; impacts to port facilities and barge companies; impacts
32398 to support industries for the commercial cruise lines; and other city and local implications.

32399 The regional economic implications of changes in costs for transporting goods, whether that is
32400 in the current shipping channel or via other modes of transportation, are also evaluated. The
32401 industries shipping goods on the CSNS are the producers of the commodities (e.g., wheat
32402 producers), as well as purchasers of commodities (e.g., fuel). The regional economic impact
32403 analysis considers how any increases in costs for shipping commodities would affect the costs
32404 to producers of commodities, and how those changes would affect regional economies. This
32405 analysis assumes that increased costs of operations would result in decreased profitability of
32406 commodities being produced, and estimates this by assuming this loss would be reflected in
32407 lost revenues to those industries. This analysis evaluates the regional economic implications of
32408 these changes, including estimates of changes in local expenditures, sales, labor income, and
32409 employment.

32410 **Commercial Cruise Line Operations**

32411 Commercial cruise lines provide tourist dollars to the regional economies they visit. The
32412 regional economic analysis addresses potential effects to these expenditures of alternatives
32413 that are anticipated to affect access of commercial cruise lines to the lower Snake River. This
32414 analysis evaluates the regional economic implications of these changes, including estimates of
32415 changes in local expenditures, sales, labor income, and employment.

32416 **Commercial Ferry Operations**

32417 The regional economic importance of the ferries to these areas as well as the implications of
32418 changes to ferry service on the regional economies that they serve is described qualitatively.

32419 **OTHER SOCIAL EFFECTS**

32420 Other social effects are community and social effects that are relevant to various MOs but are
32421 not addressed under social welfare or regional economic effects. These may include effects to
32422 public health and safety, as well as community well-being, cohesion, or identity.

32423 **Commercial Navigation and Transportation Systems**

32424 Moving commodities on the waterway results in fewer air pollutant emissions compared to
32425 truck and rail transportation. Truck transportation can emit nearly 10 times more CO₂ per ton-
32426 mile than inland barges (Kruse, Warner, and Olson 2017; refer to Section 3.8, *Air Quality and
32427 Greenhouse Gas Emissions* for additional details). As such, any reductions in navigation service
32428 that result in transportation of goods via land-based modes would generally result in increased
32429 air pollutant emissions. Alternatives may result in increased costs of operations with or without

32430 modal changes, with the potential for changes in tow configuration and/or changes in loading
32431 and number of barge trips. This analysis assesses these effects by conducting an evaluation of
32432 changes in emissions using estimates developed in the social welfare analysis of the potential
32433 tonnage that could move off the water as well as using published emission factors for inland
32434 waterway vessels and trucks.

32435 Changes in transportation modes can also have implications for public safety. For example,
32436 accident rates are generally higher for road travel than travel by either barge or rail (Inland
32437 Rivers Ports & Terminals, Inc. 2019). In addition, changes that result in increased truck usage
32438 would also add to vehicular traffic and congestion and may require additional road and highway
32439 infrastructure costs. Effects of changes in transportation modes on accident rates and
32440 congestion are discussed.

32441 Under MO3, where the navigation channel on the Snake River would become inoperable,
32442 substantial changes to port operations would be anticipated. Changes could include wholesale
32443 change in land uses at the ports. Some ports may be able to adapt to land-based shipping
32444 demands, while others may not. These structural changes to the economic base would affect
32445 regional demand for some labor categories and could affect commuting patterns as well as
32446 housing demand. The loss or transition of port operations in some communities could also
32447 result in community-level effects associated with changes in the character of the communities
32448 and community identity. These effects are discussed qualitatively for MO3 (Section 3.10.3.5).

32449 **Commercial Cruise Line Operations**

32450 The analysis considers qualitatively whether changes in cruise line tourism could affect
32451 community identity.

32452 **Commercial Ferry Operations**

32453 This analysis evaluates how changes in ferry operations may affect communities that rely on
32454 ferries for access to services, including healthcare, emergency services, tourism, and schools.

32455 **3.10.3.2 No Action Alternative**

32456 **SOCIAL WELFARE EFFECTS**

32457 **Commercial Navigation and Transportation Systems**

32458 As described in Section 3.10.2, *Affected Environment*, overall waterway traffic on the CSNS has
32459 been relatively stable over the past 20 years at an average of 54.1 million tons, with the deep-
32460 draft segment accounting for the majority of the total tonnage. Recent years have shown an
32461 increase in annual deep-draft movements, and some decline in annual shallow-draft
32462 movements that have corresponded to an increase in shuttle rail facilities built recently in the
32463 Palouse region. Industrial as well as agricultural production are projected to increase through
32464 2050, which indicates that shipping demand will continue (NW Council 2019). A portion of this
32465 agricultural production increase may be transported on the lower Snake River channel. As

32466 discussed in Section 3.10.2, *Affected Environment*, key commodities moving on the CSNS are
 32467 food and farm products (wheat, corn, and soybeans), which are being exported out of the
 32468 region. Other important commodities moving on the CSNS in 2016 included fuel, chemicals,
 32469 such as neutral sodium carbonate and fertilizers, and forest and paper products. Ongoing
 32470 trends, in terms of type and volume of commodities, are anticipated to continue under the No
 32471 Action Alternative. Transportation rate savings equals the savings associated with navigation as
 32472 opposed to other transportation modes. The average transportation rate savings for shallow-
 32473 draft traffic traveling on the Columbia and lower Willamette Rivers below Vancouver,
 32474 Washington, in 2016 was estimated to be \$266 million. The \$266 million is determined by
 32475 multiplying the per ton transportation rate savings from the Corps’ Planning Center of Expertise
 32476 for Inland Navigation and Risk Informed Economics Division (PCXIN-RED) database by the tons
 32477 moving on the waterway. The PCXIN-RED transportation rate savings database contains
 32478 estimates of transportation rate savings from the 2009 study: Transportation Rate Analysis for
 32479 the Columbia-Snake Waterway System, which was prepared for Corps by North Dakota State
 32480 University.

32481 Table 3-234. presents the average commercial navigation flow days under the No Action
 32482 Alternative for non-normal days. As indicated, most days would be expected to fall in the
 32483 normal range under the No Action Alternative, and draft would typically exceed 43 feet.

32484 **Table 3-234. Average Commercial Navigation Flow Days Under the No Action Alternative,**
 32485 **over 50 years**

River Segment	Number of Days Under Various Flow Condition (Days Per Year)					Number of Days Experiencing Draft Restriction (Days Per Year) ^{2/}					
	Low	Normal	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft
Shallow ^{1/}	6.3	313.3	26.7	9.0	2.0	–	–	–	–	–	–
Deep Draft	6.3	315.7	27.4	9.1	2.0	–	–	–	–	1.0	2.2

32486 1/ “Shallow” category applies to both the Columbia-Snake Shallow and the Columbia Shallow categories.

32487 2/ Actual number of days for draft restrictions can be a function of the availability of funding and/or dredging
 32488 equipment.

32489 Source: SCENT modeling

32490 Since 2016 is the base year for this analysis, then \$266 million represents the benefit under the
 32491 No Action Alternative for future years. Additional costs associated with extreme water flow
 32492 conditions may reduce this benefit by \$0.4 million to \$5.5 million a year. Table 3-235. presents
 32493 these average annual additional costs associated with non-normal flow conditions. As shown,
 32494 while draft restrictions could occur for traffic with drafts ranging from 20 to 45 feet, the only
 32495 vessels experiencing measurable restrictions under the No Action Alternative would be those
 32496 with drafts of 37 through 42 feet.

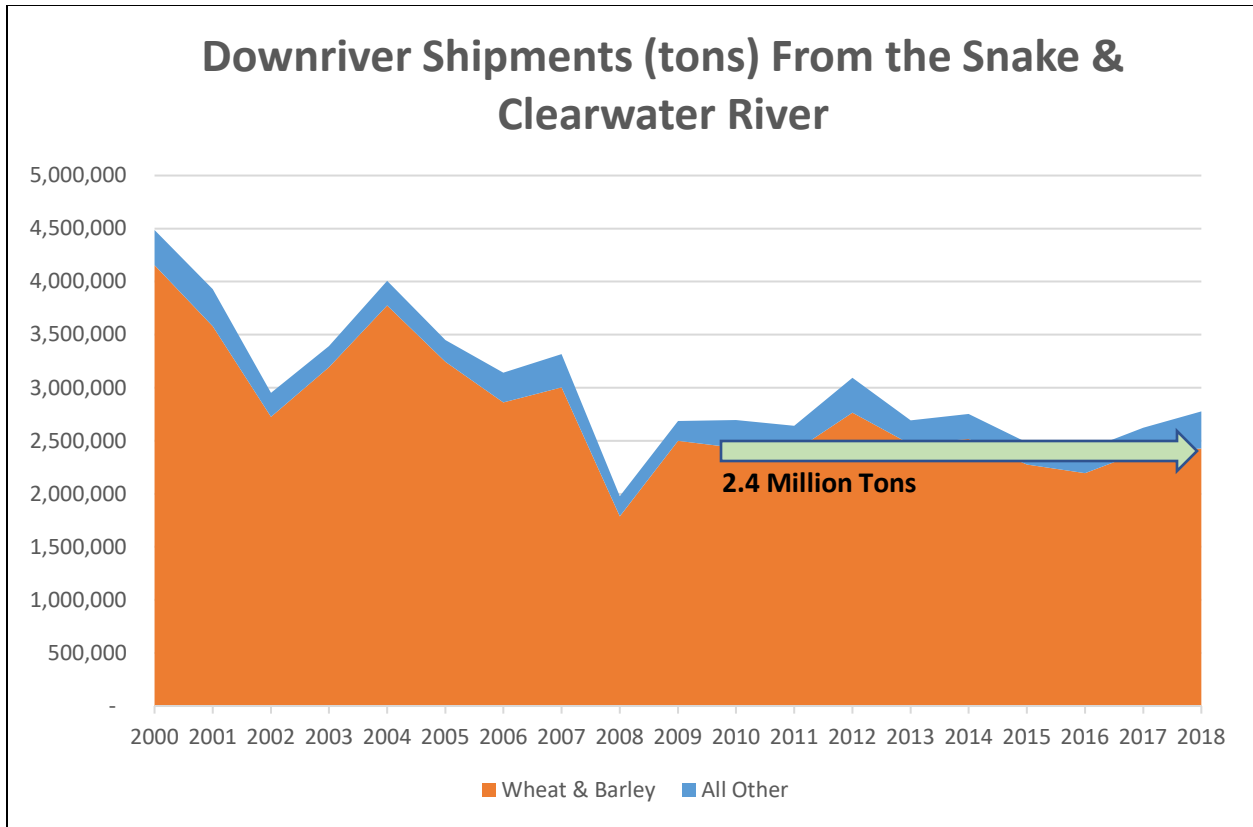
32497 **Table 3-235. Average Annual Costs of Navigation Operations Under a Range of Flow Scenarios, No Action Alternative (2019**
32498 **Dollars), 50 years**

River Segment	Costs Associated with Flow Range Categories (Non-Normal Flow Days)				Costs Associated with Draft Restrictions (Non-Normal Flow Days)						
	Low	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft	Total
Columbia-Snake Shallow	–	\$829,000	\$1,155,000	\$578,000	–	–	–	–	–	–	\$2,562,000
Columbia Shallow	–	\$149,000	\$86,000	\$124,000	–	–	–	–	–	–	\$359,000
Deep Draft	\$539,000	\$993,000	\$1,419,000	\$2,453,000	\$1,000	\$11,000	\$16,000	\$28,000	\$50,000	\$40,000	\$5,550,000
Total	\$539,000	\$1,971,000	\$2,661,000	\$3,155,000	\$1,000	\$11,000	\$16,000	\$28,000	\$50,000	\$40,000	\$8,472,000

32499 Note: Costs of operations under normal flow range categories are not anticipated to be affected under any alternatives and are therefore excluded from the
32500 table. The “Columbia-Snake Shallow” category refers to traffic that travels on both the Columbia and Snake Rivers. The “Columbia Shallow” category refers to
32501 traffic only traveling the Columbia Shallow river segment. These are mutually exclusive categories.

32502 The volume of grain that moves down the lower Snake River is assumed to be constrained to
32503 2.4 million tons under the No Action Alternative. Figure 3-210 displays the volume of grain
32504 moving down the lower Snake River from 2000 to 2018 from the Waterborne Commerce data.
32505 The amount of grain moving by barge is a result of a combination of factors, including total
32506 production, which has been relatively stable over time, as well as market driven forces,
32507 including competition between and within transportation modes, which change from year to
32508 year. One of the market forces obviously are the market prices for grain, which are primarily
32509 determined internationally. The price point for grain at any one point in time may cause the
32510 growers and elevator managers to empty or fill their storage, leading to volume
32511 movements that vary from year to year. Further, some occasions have arisen in the market
32512 when it is more profitable for an elevator to sell railroad future car contracts for the secondary
32513 premium, moving grain to the river during that time. Additionally, over time the advent of new
32514 shuttle facilities has shaped the competitive geographical map in the region. As shown, the
32515 total grain volumes using the river have varied but generally declined since the early 2000s,
32516 with more precipitous declines since the opening of two additional shuttle rail facilities (McCoy
32517 and High Line Shuttle Terminals), followed by a decade of relative stable volumes of grain
32518 movements. In light of these historic trends the volume of grain shipped down the lower Snake
32519 River is assumed to remain constant over time, even as modest increases in grain production
32520 and technological improvements in yield are anticipated over time. As such, an estimate of 2.4
32521 million tons was chosen to model future downbound grain shipments. The estimate of 2.4
32522 million tons represents the 10-year average of downbound grain and barley shipments on the
32523 lower Snake River as well as the most recent data volume (2018) shipped in 2018, the latest
32524 year of reported data.

32525 Table 3-236. summarizes specific assumptions about grain movements under the No Action
32526 Alternative, which were developed for the transportation optimization model, and then
32527 parameterized for the No Action Alternative. Figure 3-211 depicts shipping patterns by mode
32528 for grain shippers under the No Action Alternative. Specifically, the figure illustrates the
32529 highway flows of grain shipments, the location of origination points used in the transportation
32530 optimization model, river port terminals along the Columbia/Snake navigation channel (green
32531 circles) and shuttle rail terminals (orange dots). The intensity of highway flows is represented
32532 by thicker lines that change colors (moving toward dark red) as the volumes increase. The No
32533 Action Alternative illustrates the intensity of highways being used to move grain in the existing,
32534 base-case scenario and it shows thicker lines for highways connecting river port terminals and
32535 shuttle rail facilities. The size of the circles also reflects the increasing volume moving through
32536 each facility type (river port, shuttle rail, and elevator with rail) as grain is consolidated from
32537 farm to country elevators and on toward the tidewater terminals for export.



32538

32539 **Figure 3-210. Recent Grain Shipments on the Snake River, with No Action Alternative Forecast**

32540 Note: Large decreases in grain tons during 2002 and 2008 are more reflective of exogenous factors and do not
 32541 suggest an isolated effect from new unit train facilities. In 2002, there was a drought in eastern Washington that
 32542 reduced grain supply. In 2008, the global recession influenced demand for grain.
 32543 Source: Corps Waterborne Commerce data (2018).

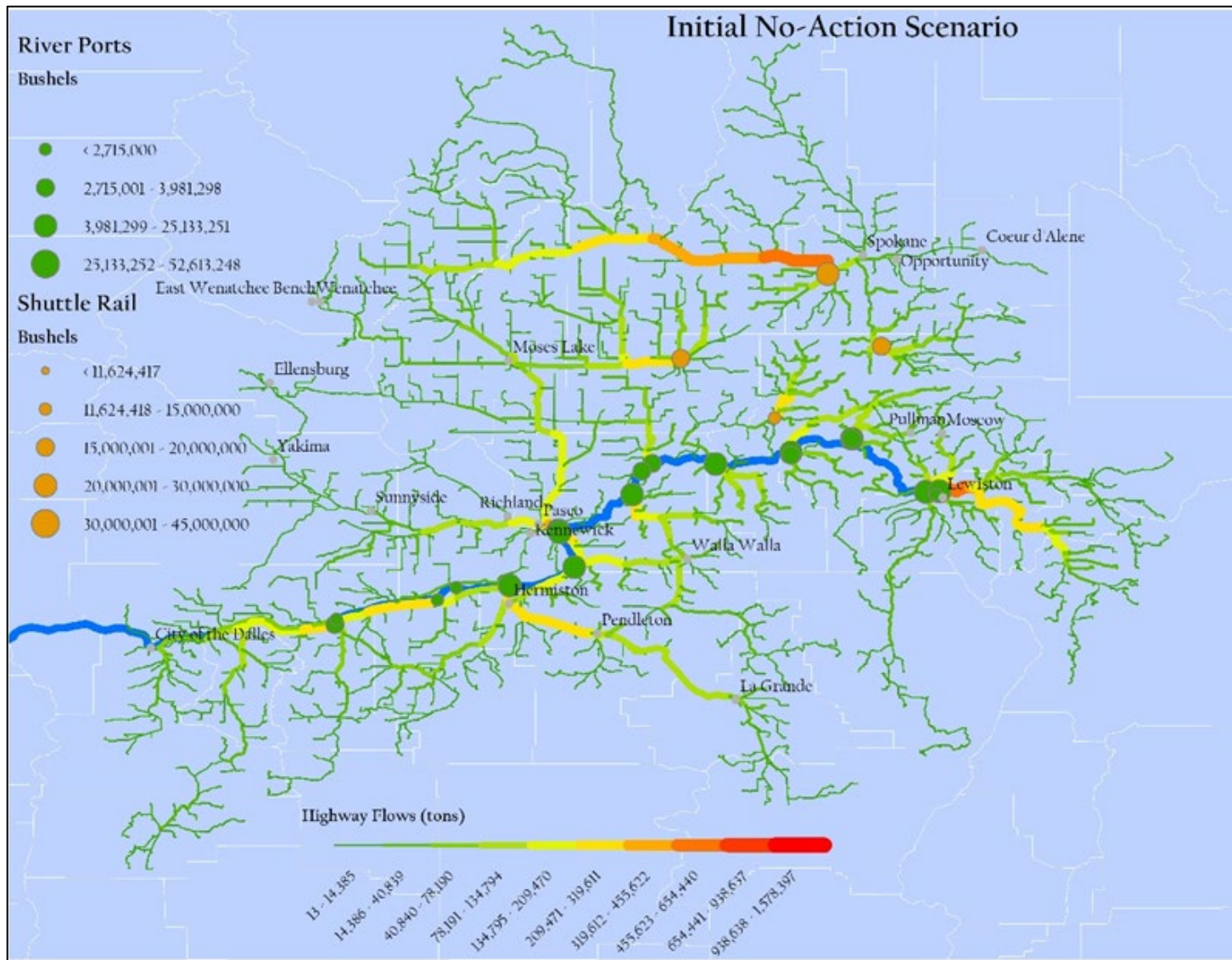
32544 **Table 3-236. Modal Transit of Wheat and Barley in Eastern Washington and Idaho Under the No Action Alternative**

Origin-Destination Type	Mode	Volume (bushels)	Total Cost	Cents/Bushel	Ton-Miles	Average Distance (miles one direction)
Farm to Elevator (no rail)	Truck	1,413,000	\$330,740	\$0.23	2,629,978	28.2
Farm to Elevator (with rail)	Truck	17,916,392	\$4,022,993	\$0.22	30,355,061	25.7
Farm to Elevator (shuttle rail)	Truck	58,178,017	\$12,605,471	\$0.22	91,038,006	23.7
Farm to River Port	Truck	125,075,861	\$34,581,616	\$0.28	322,393,030	39.1
Elevator to Elevator with Rail	Truck	0	\$0	N/A	0	N/A
Elevator to Elevator Shuttle Rail	Truck	0	\$0	N/A	0	N/A
Elevator to River Port	Truck	1,413,000	\$396,910	\$0.28	3,757,039	40.3
Elevator with Rail to Shuttle Rail	Truck	0	\$0	N/A	0	N/A
Elevator with Rail to Shuttle Rail	Rail	13,289,664	\$3,193,277	\$0.24	29,669,201	74.4
Elevator with Rail to River Port	Truck	4,626,728	\$1,389,845	\$0.30	13,783,455	45.1
Elevator with Rail to River Port	Rail	0	0	N/A	0	0
Shuttle Rail Elevator to Portland	Rail	71,467,681	\$36,258,211	\$0.51	789,185,132	368.1
River Port to Portland ^{1/}	Barge	131,115,589	\$52,126,818	\$0.40	1,086,083,464	276.1
Total	–	202,583,270	\$144,905,881	\$0.72 (avg)	2,368,894,365	–

32545 Note: avg = average.

32546 1/ Assumes 2.1 million tons of grain moving down the Snake River via barge.

32547 Source: Transportation optimization model, parameterized to reflect current conditions



32548
 32549
 32550

Figure 3-211. No Action Alternative Shipping Routes

Source: Transportation optimization model, parameterized to reflect current conditions

32551 **Dredging Activities**

32552 Under the No Action Alternative, the navigation system would continue to be maintained as
32553 required under existing authorities and operational plans. No change or measurable difference
32554 in the average annual channel dredging volume would be expected. Based on the river
32555 mechanics analysis for the No Action Alternative, the estimated annual volume of sediment
32556 depositing in the lower Columbia River Federal Navigation Channel is around 6.68 MCY per
32557 year. Note that most of the dredging activity is in the deep-draft channel, as little dredging
32558 occurs between the confluence of the lower Snake River to Bonneville Dam on the lower
32559 Columbia River. The average annual cost for maintaining the lower Columbia River navigation
32560 channel is estimated at \$67.07 million per year, based upon the annual dredging costs from
32561 2016 to 2018. Under the No Action Alternative, it is anticipated that dredging activities and
32562 associated dredging costs would continue.

32563 Most dredging for the shallow draft of the CSNS occurs on the Snake River at the confluence of
32564 the Clearwater River with the Snake River. No change or measurable difference in the average
32565 annual channel dredging volume is expected on the lower Snake River Based on the river
32566 mechanics analysis for the No Action Alternative, the estimated annual volume of sediment
32567 requiring dredging to maintain the lower Snake River navigation channel is 124,000 cubic yards
32568 per year at an estimated cost of \$3.04 million (annual equivalent).

32569 Current dredging operations would be anticipated to continue under the No Action Alternative.
32570 The total annualized cost of dredging for the CSNS is \$70.1 million (annual equivalent).

32571 **Commercial Cruise Line Operations**

32572 As discussed in Section 3.10.2, *Affected Environment*, approximately 18,000 passengers cruised
32573 along the river (Pacific Northwest Waterways Association [PNWA] 2017). Passenger ridership
32574 on lower Snake River cruise lines has been growing in recent years. The Columbia River outsold
32575 the Mississippi River in 2018 for the first time, as all six operating cruise ships were sold out
32576 from May to October (Macuk 2019). One cruise company more than doubled its passenger
32577 capacity on the Columbia-Snake in 2016 with a new ship (Cruise Industry News 2015), and then
32578 introduced another large river cruise ship in 2018 (Macuk 2019). In 2019, seven river cruise
32579 ships have dedicated Columbia-Snake River itineraries (Macuk 2019). Given this, under the No
32580 Action Alternative, opportunities for commercial cruise ships would be anticipated to continue
32581 throughout the CSNS, and may increase over time. Cruise ships and other recreational boaters
32582 would continue to use the CSNS and contribute to the local economies along the route under
32583 the No Action Alternative.

32584 **Commercial Ferry Operations**

32585 The H&H data indicates that water surface elevations on Lake Roosevelt would be sufficient to
32586 allow operation of the Inchelium-Gifford Ferry every day out of the year under the No Action
32587 Alternative in average water years as well as in dry water years. As stated in Section 3.10.2,
32588 *Affected Environment*, the minimum operating elevation of the ferry is 1,229 feet NGVD29. In

32589 larger runoff years under the No Action Alternative, the ferry would be inoperable for certain
32590 periods when Lake Roosevelt is drafted deeper in April and May in order to reduce potential
32591 flooding effects downstream. In these “wet” water years, defined as conditions under the
32592 highest 20th percentile forecasted volume at The Dalles Dam, the Inchelium-Gifford Ferry
32593 would not be able to operate for approximately 27 days in the year (or 7 percent of the year in
32594 wet years). Longer inoperable periods would be expected under wetter years that require more
32595 FRM space. Under the No Action Alternative, Grand Coulee Dam is operated to provide system
32596 FRM space in Lake Roosevelt in the winter and spring months. This space requirement is
32597 determined by water supply forecasts at The Dalles and in years with higher water supply
32598 conditions space requirements can result in drafts below 1,229 feet NGVD29 in Lake Roosevelt.
32599 No other operations require drafts below this elevation.

32600 Analysis indicates that operations of Grand Coulee Dam under the No Action Alternative would
32601 allow the same level of use of the Inchelium-Gifford Ferry as seen in the recent past. There
32602 would be no overall increase in the length of shutdowns. This general level of use and length of
32603 shutdowns in wet years would be expected to continue under the No Action Alternative.

32604 **REGIONAL ECONOMIC EFFECTS**

32605 **Commercial Navigation and Transportation Systems**

32606 As described in Section 3.10.2, *Affected Environment*, the navigation industry contributes
32607 substantially to the regional economies in the study area. Ports along the river serve to
32608 encourage economic development within their district, region, and state. Wheat and other
32609 grain farming, port operation and storage facilities, barge transportation, and other
32610 commodities such as sand, gravel, forest products, and fertilizer use the river for cost-effective
32611 transportation and provide jobs and income to regional economies. These activities would
32612 continue under the No Action Alternative.

32613 ***Snake Shallow (Regions C and D)***

32614 Under the No Action Alternative, transportation costs for individual farmers shipping grain to
32615 the Port of Portland varies according to the particular attributes of each operation, including its
32616 proximity to rail, river, and particulars of rates negotiated with farming cooperatives and
32617 shipping companies. In addition to these factors, some farmers have lower costs of operations
32618 than others. In particular, some farmers may have high costs of owning or leasing lands relative
32619 to others. Despite all of these variations, farmers in the Northwest have generally lower
32620 shipping costs relative to farmers in the Midwest, who also ship grain to the Port of Portland,
32621 but have substantially longer travel distances. As such, farmers in the Northwest would likely
32622 continue cost advantages relative to other regions under the No Action Alternative.

32623 A small number of companies specialize in operating barges and tow boats on the CSNS. These
32624 operators employ approximately 450 employees, which range from captains and crews to
32625 tugboat operators, shipping handlers, to boat builders. Many crew members permanently
32626 reside in the greater Portland area, but some reside in upriver areas (Tidewater Barge Lines and

32627 Shaver Transportation Company 2020). These companies report that many of their employees
32628 are long-term, having niche experience and skills that would likely be difficult to transfer to
32629 other industries. Under the No Action Alternative, these companies would continue to operate
32630 and compete with rail and truck operators for shipping business.

32631 There are four primary commercial ports in the Snake River Shallow section that runs between
32632 Pasco, Washington, and Lewiston, Idaho. These include the Port of Lewiston, the Port of
32633 Clarkston, the Port of Whitman County (with sites at Wilma, Almota, and Central Ferry), and the
32634 Port of Garfield. These ports are important regional hubs for both the navigation industry and
32635 the wider economy. Ports often own and lease buildings, land, and storage facilities.

32636 The Port of Lewiston reports that it contributed \$390 million (2014 dollars) in direct regional
32637 spending and supported 1,840 direct jobs from businesses associated with properties owned or
32638 developed by the port in 2017 (Peterson 2014). It serves as an important regional economic
32639 hub for a variety of industries, notably in the manufacturing sector. The port itself employs
32640 seven people and operates on a budget that ranges from \$1.8 million to \$2.3 million (2014
32641 dollars). Its primary sources of income are terminal revenue, rental income, and tax levies
32642 (Peterson 2014). Businesses in cities and towns around the larger ports, including Lewiston and
32643 Clarkston in particular, have evolved to maximize use of the river in its current state. In
32644 particular, a large papermill located in Lewiston, Idaho, is the largest employer in the area
32645 (Cities of Lewiston, Clarkston, and Asotin 2019). The papermill utilizes the river system for
32646 barging some of its input materials, including specialized wood chips, upriver to the facility
32647 (Clearwater Paper 2020; Tidewater Barge Lines 2020). In addition, slackwater conditions in
32648 Lewiston, Clarkston, and Asotin have made the area desirable for motor boating. As a result, a
32649 number of aluminum boat-building companies are located in these towns (Cities of Lewiston,
32650 Clarkston, and Asotin 2019). While these businesses may not utilize the commercial barges on
32651 the river, these commercial businesses benefit from the navigation system existing in its current
32652 state.

32653 Grain elevators and other storage facilities are an important part of the commercial navigation
32654 infrastructure for many ports. The Wilma site has the capacity to store 4.6 million bushels of dry
32655 peas and grain (Port of Whitman County 2015; World Port Source 2019b). The Almota site has
32656 the capacity to store 3.7 million bushels (Port of Whitman County 2015). The Central Ferry site
32657 has the capacity to store 4.6 million bushels (Port of Whitman County 2015). The Port of
32658 Garfield owns 21 storage units (Port of Garfield 2019). The Port of Lewiston has a capacity of
32659 9.1 million bushels of covered storage and an additional 2 million bushels of outside storage
32660 (Idaho Cooperating Agencies 2019).

32661 Under the No Action Alternative, the shortline rail, Palouse River and Coulee City (PCC), owned
32662 by WSDOT would continue its current planning regime (draft plan published in 2019 for public
32663 review). Under the current plan, the PCC system would be improved strategically, largely to
32664 maintain critical infrastructure for existing needs, including replacing rail ties, bridges, ballasts,
32665 and other minor maintenance activities. Currently, the Washington State legislature has
32666 allocated \$6.7 million every two years through 2031 to the PCC for these improvement

32667 projects. Additionally, WSDOT has plans to upgrade the entire PCC network to handle 286,000-
32668 pound cars. These upgrades are necessary to remain compliant with Class I rail industry
32669 standards. To upgrade the entire rail network to the 286,000-pound car standard, WDOT would
32670 have to invest \$150 million (WSDOT 2020).

32671 Under the No Action Alternative, highways in the region would continue to be maintained on
32672 an as-needed basis.

32673 ***Columbia Shallow (Region D)***

32674 There are 10 primary commercial ports in the Columbia Shallow river section, which runs from
32675 Portland Oregon (below Bonneville Dam), to Pasco, Washington, below McNary Dam. These are
32676 the Port of Benton, the Port of Kennewick, the Port of Pasco, the Port of Walla Walla, the Port
32677 of Umatilla, the Port of Morrow, the Port of Arlington, the Port of The Dalles, the Port of
32678 Klickitat, and the Port of Camas-Washougal. Many of these ports play an important role in
32679 economies of the Tri-Cities area of Washington and are proud of their role in providing facilities
32680 for barge shipments of grain from the area to the seacoast terminals in addition to other
32681 commodities. The Port of Benton reports that it supports over 2,000 direct jobs (Port of Benton
32682 2019), while the Port of Kennewick reports that it has 13 staff and supports 1,550 jobs in the
32683 area (Port of Kennewick 2019). In addition to these sites, the Ports of Hood River and Skamania
32684 are primarily recreational ports in this region.

32685 ***Deep Draft (Region D)***

32686 There are six primary commercial ports included in the deep-draft river section, which runs
32687 from Portland, Oregon, to the ocean. These are the Port of Portland, the Port of Vancouver, the
32688 Port of St. Helens, the Port of Kalama, the Port of Longview, and the Port of Astoria. Most of the
32689 cargo that goes through the deep-draft ports is shipped directly via rail or truck from inland
32690 areas and exported, while some cargo travels down the river from the shallow-draft areas of
32691 the CSNS. Most of the regional economic effects are concentrated in the export industry, but
32692 the commerce generated by the export hub is nonetheless estimated to support 40,000 local
32693 jobs (PNWA 2017). Additional smaller commercial ports include Ilwaco, Woodland, and
32694 Chinook. In addition to these ports, the Port of Columbia County is primarily a recreational port.

32695 **Commercial Cruise Line Operations**

32696 Under the No Action Alternative, commercial cruise ship ridership would be anticipated to
32697 continue throughout the CSNS and may increase over time. Cruise ship passengers would
32698 continue to spend money on restaurants, souvenirs, and other recreation activities in ports,
32699 stimulating the local and regional economy under the No Action Alternative. This analysis
32700 assumes that passengers would spend approximately \$124 per day (2019 dollars) on 7-day
32701 cruises (Dean Runyan Associates 2015; Port of Lewiston/Shoreline Excursions 2019). Using
32702 these assumptions, the annual 18,000 cruise ship passengers per year would spend
32703 approximately \$15.6 million annually under the No Action Alternative as part of cruise line trips.
32704 These expenditures would create demand for approximately 230 jobs in the region, and would

32705 generate \$6.2 million in labor income, and \$17.8 million in output (sales). Most of these effects
32706 would be in Region C, with remaining expenditures in Region D.

32707 **Commercial Ferry Operations**

32708 Under the No Action Alternative, average daily traffic for passengers on the Inchelium-Gifford
32709 Ferry, which primarily serves the Colville Reservation, would continue to be approximately 410
32710 passengers per day, with interruptions of service of approximately 27 consecutive days in wet
32711 water years due to lower reservoir elevations in Lake Roosevelt. "Wet" water years are defined
32712 as conditions under the highest 20th percentile forecasted volume at The Dalles Dam. In wet
32713 years, the reservoir may be drawn down to accommodate higher-than-average inflows. Under
32714 the No Action Alternative, the ferry would continue to serve a role to allow community
32715 members to access services on both sides of the river, which would include expenditures on
32716 food and healthcare, among other services.

32717 **OTHER SOCIAL EFFECTS**

32718 **Commercial Navigation and Transportation Systems**

32719 As described in the air quality analysis, transportation by inland navigation produces lower air
32720 emissions than other transportation modes, including rail and truck per ton-mile (Kruse,
32721 Warner, and Olson 2017). Emissions from the navigation industry would remain stable under
32722 the No Action alternative. Transportation via inland navigation also has generally lower
32723 vehicular accident rates than road or rail and does not result in road traffic (GAO 2011). As
32724 described above, port facilities in the region add to the character of river communities and
32725 contribute to a sense of community identity. Some tribes have commented that there are
32726 ongoing social and cultural effects as well as socioeconomic costs to Indian tribes and tribal
32727 communities from present and cumulative effects of the current navigation system that would
32728 continue under the No Action Alternative. These aspects of the presence of ports would
32729 continue under the No Action Alternative.

32730 **Commercial Cruise Line Operations**

32731 Commercial cruise lines would continue to provide tourist visitation, and may continue to
32732 increase operations, under the No Action Alternative. These activities may contribute to the
32733 community identity of ports of call as important tourist destinations.

32734 **Commercial Ferry Operations**

32735 The Inchelium-Gifford Ferry serves an isolated tribal community by offering access and
32736 connection to local services on both sides of the river. As described in Section 3.10.2, *Affected*
32737 *Environment*, the ferry is important to commuters, schoolchildren, emergency services, tourists,
32738 and the tribe as a whole. The ferry would likely continue operations under the No Action
32739 Alternative. The average daily number of passengers was 410 in 2018 (CTCR 2019). This would
32740 continue under the No Action Alternative.

32741 **SUMMARY OF EFFECTS – NO ACTION ALTERNATIVE**

32742 The navigation industry would continue to operate on the Columbia and lower Snake Rivers
32743 with continued export activity under the No Action Alternative. The availability of low-cost
32744 barge transportation would continue to provide economical and safe shipping for a wide range
32745 of commodities up to Lewiston, Idaho. Barge companies would continue to employ workers to
32746 run barges up to Lewiston, Idaho. Ports located along both rivers would continue to provide
32747 development opportunities for communities and support jobs and income in the region.
32748 Current dredging operations would be anticipated to continue under the No Action Alternative.
32749 Air emissions associated with transportation of wheat out of the Northwest region would
32750 continue to be low relative to other shipping options. Transportation costs to Northwest
32751 farmers would continue to be low relative to inland areas.

32752 Commercial activity associated with cruise ships would continue to bring visitors and tourist
32753 dollars to the communities along the lower Columbia and lower Snake Rivers. The Inchelium-
32754 Gifford Ferry on Lake Roosevelt would continue to provide commuters, schoolchildren, tourists,
32755 and others with convenient and low-cost transportation for daily activities and needs.
32756 Table 3-237. provides a summary of effects of navigation and transportation under the No
32757 Action Alternative.

32758 **Table 3-237. Economic Effects of Navigation and Transportation Under the No Action Alternative, over 50 years**

Region	Social Welfare Effects	Regional Economic Effects	Other Social Effects
Region B	Ferries on Lake Roosevelt would operate throughout the year. The Inchelium-Gifford Ferry would not be able to operate for approximately 27 days a year in wet years. ^{1/}	Ridership of the ferry (150,000 passengers in 2018) would continue. Ferry operations would result in regional economic benefits to communities at destination locations, in addition to providing employment opportunities.	Ferries provides connections between remote communities in Lake Roosevelt area.
Region C (Snake Shallow)	The Snake Shallow segment of the CSNS would continue to operate consistent with current trends. Cruise line operations would continue at current levels, with potential growth over time. Dredging would continue periodically, consistent with current operations.	Four primary commercial ports would continue to operate and support local jobs and income: Ports of Lewiston, Clarkston, Wilma, Almota, Central Ferry, and Garfield. Cruise lines would provide regional economic benefits to some port cities, particularly Lewiston and Clarkston.	Sense of community and identity associated with ports would continue. Accident rates and air emissions would remain low relative to other transportation modes. Ongoing social and cultural effects as well as socioeconomic costs to Indian tribes and tribal communities from present and cumulative effects of the current navigation system would continue.
Region D (Columbia Shallow)	The Columbia Shallow segment of the CSNS would continue to operate consistent with current levels. Cruise line operations would continue at present levels, with potential growth over time. Little dredging would occur in this reach, consistent with current operations.	Ten primary commercial ports would continue to operate and support local jobs and income: Ports of Benton, Kennewick, Pasco, Walla Walla, Umatilla, Morrow, Arlington, The Dalles, Klickitat, and Camas-Washougal. Cruise lines would provide regional economic benefits, including employment, at some port cities, particularly Portland, Oregon.	Sense of community and identity associated with ports would continue.
Region D (Deep Draft)	The deep-draft segment of the CSNS would continue to operate consistent with current levels. Cruise line operations would continue at present levels, with potential growth over time. Considerable dredging operations would continue, consistent with current operations.	Six primary ports would continue to operate and support jobs and income: Ports of Portland, Vancouver, St. Helens, Kalama, Longview, and Astoria. Cruise lines would provide regional economic benefits, including employment, to some port cities.	Sense of community and identity associated with ports would continue.

32759 1/ "Wet" water years are defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam. In wet years, the reservoir may be
32760 drawn down to accommodate higher than average inflows.

32761 **3.10.3.3 Multiple Objective Alternative 1**

32762 A number of planned structural measures under MO1, such as upgrading spillway weirs, are
32763 unlikely to have measurable impacts to commercial navigation or cruise lines in the CSNS
32764 because they do not affect flow or elevation of water. However, the following operational
32765 measures have the potential to affect operations on the CSNS. In particular:

32766 *Summer Spill Stop Trigger, Modified Dworshak Summer Draft, and Planned Draft Rate at Grand*
32767 *Coulee* measures may alter reservoir levels and/or the quantity or the timing of the flows in the
32768 Snake River and lower Columbia River (or both) and have the potential to impact how vessels
32769 move on the CSNS. Additionally, commercial ferry operations on Lake Roosevelt potential could
32770 be affected by operational changes that result in lower reservoir levels in the early spring at
32771 Grand Coulee. Other operational measures within MO1 may have notable effects on water
32772 levels and flow in upstream regions, but these flow changes are increasingly diluted as they
32773 reach the mainstem Columbia River downstream.

32774 **SOCIAL WELFARE EFFECTS**

32775 **Commercial Navigation and Transportation Systems**

32776 The H&H data used as input into the SCENT model, as presented in Table 3-238., shows that
32777 MO1 would result in a negligible change in non-normal flow days when compared to the No
32778 Action Alternative.

32779 **Table 3-238. Changes in Average Commercial Navigation Flow Days Under Multiple Objective**
32780 **Alternative 1 Relative to No Action Alternative, over 50 years**

River Segment	Number of Days Under Various Flow Condition (Days Per Year)					Number of Days Experiencing Draft Restriction (Days Per Year)					
	Low	Normal	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft
Shallow	< -0.1	0.4	<0.1	< -0.1	< -0.1	-	-	-	-	-	-
Deep Draft	-	-	-	-	-	-	-	-	-	< -0.1	< -0.1

32781 Note: The “Shallow” categories include both the Columbia-Snake Shallow category, which refers to traffic that
32782 traveled on both the Columbia and Snake Rivers, and the Columbia Shallow, which presents the impact to traffic
32783 only traveling on the Columbia.

32784 Source: SCENT modeling

32785 Table 3-239. for MO1 presents anticipated changes in average annual operating costs that
32786 would occur under MO1 as a result of flow changes. Costs of operations under normal flow
32787 range categories would not be affected under MO1.⁹

32788 The average annual change in transportation costs under MO1 in the Columbia-Snake Shallow
32789 category is estimated to be \$9,000 more than the No Action Alternative. Less than \$1,000 in

⁹ The Columbia-Snake Shallow category refers to traffic that traveled on both the Columbia and Snake Rivers while the Columbia Shallow presents the impact to traffic only traveling on the Columbia River.

32790 increased average annual costs would occur under MO1 for Columbia Shallow operations. The
32791 average annual extra transportation costs for transportation in the deep-draft segment are
32792 estimated to be \$4,000 more than the No Action Alternative under MO1. The driver behind the
32793 minor increases in costs is additional days of low flow in late summer causing draft restrictions
32794 for some vessels. These increases in low flow conditions are primarily associated with the
32795 combination of the *Lake Roosevelt Additional Water Supply* and *Modified Dworshak Summer*
32796 *Draft* measures.

32797 As shown in Table 3-239., the total increase in average annual costs to commercial navigation
32798 operations would be approximately \$14,000.

32799 **Table 3-239. Changes in Average Annual Costs of Commercial Navigation Operations Under Multiple Objective Alternative 1**
32800 **Relative to No Action Alternative (2019 Dollars), over 50 years**

River Segment	Change in Costs Associated with Flow Range Categories				Changes in Costs Associated with Draft Restrictions						
	Low	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft	Total
Columbia-Snake Shallow	–	\$6,000	\$4,000	–	–	–	–	–	–	–	\$9,000
Columbia Shallow	–	\$0	\$0	\$0	–	–	–	–	–	–	<\$1,000
Deep Draft	–	–	–	–	–	<\$1,000	–	\$1,000	\$1,000	<\$1,000	\$4,000
Total	\$0	\$6,000	\$4,000	\$0	\$0	<\$1,000	\$0	\$1,000	\$1,000	<\$1,000	\$14,000

32801 Note: The Columbia-Snake Shallow category refers to traffic that traveled on both the Columbia and Snake Rivers while the Columbia Shallow presents the
32802 impact to traffic only traveling on the Columbia. These effects are all within one standard deviation of the No Action Alternative conditions. Costs of operations
32803 under normal flow range categories are not anticipated to be affected under any alternatives and are therefore excluded from the table. Numbers may not
32804 sum due to rounding.

32805 Source: SCENT modeling

32806 **Dredging Operations**

32807 Negligible changes to dredging operations would occur under MO1 because anticipated
32808 changes to river flows and stages would not have effects on sediment transport in areas used
32809 by commercial navigation.

32810 **Commercial Cruise Line Operations**

32811 Negligible changes to cruise ship operations would occur under MO1 because anticipated
32812 changes to river flows and stages would not affect timing or use of the navigation channel.

32813 **Commercial Ferry Operations**

32814 H&H data indicates that water surface elevations on Lake Roosevelt would be sufficient to allow
32815 operation of the Inchelium-Gifford Ferry every day out of the year under MO1 in average water
32816 years as well as in dry water years. In larger runoff years, the ferry would be inoperable for
32817 certain periods when Lake Roosevelt is drafted deeper in April and May in order to reduce
32818 potential flooding effects downstream, similar to the No Action Alternative. In these “wet”
32819 water years, defined as conditions under the highest 20th percentile forecasted volume at The
32820 Dalles Dam, the Inchelium-Gifford Ferry would not be able to operate for approximately 36
32821 consecutive days in the year under MO1 (or 10 percent of the year in wet years), which is 9
32822 days more than under the No Action Alternative (a 33 percent increase). This would result from
32823 changes in operations at Grand Coulee Dam under this alternative. The average daily number of
32824 passengers on the ferry is 410 (FHWA 2017). At this rate, approximately 3,700 ferry trips could
32825 be affected in wet years by this change. Longer inoperable periods would be expected in wetter
32826 years that require more FRM space. This is likely to be caused by the *Winter System FRM Space*,
32827 *Planned Draft Rate at Grand Coulee*, and *Update System FRM Calculation* measures.

32828 **REGIONAL ECONOMIC EFFECTS**

32829 **Commercial Navigation and Transportation Systems**

32830 Average annual costs to the navigation industry would increase by approximately \$14,000
32831 under MO1. These effects are not likely to result in noticeable effects to regional economies.

32832 **Commercial Cruise Line Operations**

32833 Negligible effects to commercial cruise line operations would occur under MO1. Given this,
32834 effects to regional economies are not anticipated.

32835 **Commercial Ferry Operations**

32836 MO1 would result in a loss of 9 days of operations by the Inchelium-Gifford Ferry in wet years
32837 (a 33 percent change from the No Action Alternative), which could represent 3,700 fewer ferry
32838 trips. Longer inoperable periods would be expected in wetter years that require more FRM
32839 space. In those years and for those days, expenditures associated with these trips via ferry
32840 would likely be delayed or would not take place in the same locations.

32841 **OTHER SOCIAL EFFECTS**

32842 **Commercial Navigation and Transportation Systems**

32843 Average annual costs to the navigation industry would increase by approximately \$14,000
32844 under MO1. These effects are not likely to result in noticeable changes to other social effects,
32845 including changes in air emissions accident rates, or infrastructure costs under MO1.

32846 **Commercial Cruise Line Operations**

32847 Negligible effects to commercial cruise line operations would occur under MO1. Given this,
32848 changes to other social effects are not anticipated under MO1.

32849 **Commercial Ferry Operations**

32850 MO1 would result in a loss of 9 days of operations by the Inchelium-Gifford Ferry in wet years.
32851 Longer inoperable periods would be expected in wetter years that require more FRM space. In
32852 those years and for those days, travel from remote communities that use the ferry would not
32853 be able to occur. Changes in access by the remote communities during those days would
32854 reduce access to healthcare and educational facilities, in addition to food and shopping
32855 resources. Without the ferry, commuters and others who need to make the trip must take a 70-
32856 mile detour, which adds substantial mileage, gas costs, time, air emissions, and other effects
32857 (Spokesman-Review 2017). Since the ferry is free and reduces driving time and distance, the
32858 loss of ferry service would create additional transportation costs.

32859 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 1**

32860 MO1 would result in negligible increases in average annual costs for deep-draft navigation and
32861 shallow-draft navigation. The increase in costs for deep-draft navigation would result from
32862 additional days of low flows, which would require an increase in the number of tug operations.
32863 Overall, this would represent a change in average annual costs of \$14,000 to the industry,
32864 representing a negligible (less than 0.1 percent) increase in costs in comparison to the No
32865 Action Alternative. Effects to the cruise line industry would be negligible.

32866 Adverse effects would occur to the Inchelium-Gifford Ferry because it would be able to operate
32867 9 days fewer under MO1 than under the No Action Alternative in wet years, for a total of 36
32868 consecutive days, which could represent 3,700 ferry trips. Longer inoperable periods would be
32869 expected in wetter years that require more FRM space. During those years minor social welfare
32870 effects could be experienced due to the longer inoperable period. Minor regional economic
32871 effects due to loss or redistribution of expenditures associated with the ferry trips could also
32872 occur. Changes in access to healthcare and educational facilities, in addition to food and
32873 shopping resources, could result in moderate adverse effects. Other ferries would not be
32874 affected under MO1.

32875 Table 3-240. provides a summary of the navigation and transportation system effects of MO1.

32876 **Table 3-240. Changes in Economic Effects of Navigation and Transportation Under Multiple**
32877 **Objective Alternative 1 Relative to the No Action Alternative, over 50 years**

Region	Social Welfare Effects	Regional Economic Effects	Other Social Effects
Region B	Minor effects due to decrease in Inchelium-Gifford Ferry operations of an additional 9 days in wet years (for a total of 36 consecutive days). ^{1/} Longer inoperable periods would be expected in wetter years that require more FRM space.	Minor effects due to loss or redistribution of expenditures associated with approximately 3,700 Inchelium-Gifford Ferry trips in wet years. Longer inoperable periods would be expected in wetter years that require more FRM space.	Moderate effects due to reduced access to healthcare and other services of the Inchelium-Gifford for 9 days in wet years. Longer inoperable periods would be expected in wetter years that require more FRM space.
Region C (Snake Shallow)	Negligible effects anticipated to commercial navigation or commercial cruise lines. Average annual cost increases represent less than 0.1 percent of total costs of navigation operations.	Negligible effects from increased costs to cruise lines or shipping operations. Negligible effects to port operations.	No effects.
Region D (Columbia Shallow)	Negligible effects anticipated to commercial navigation or commercial cruise lines. Average annual cost increases represent less than 0.1 percent of total costs of navigation operations.	Negligible effects from increased costs to cruise lines or shipping operations. Negligible effects to port operations.	No effects.
Region D (Deep Draft)	Negligible effects anticipated. Average annual cost increases represent less than 0.1 percent of total costs of navigation operations. No effects to ferries.	Negligible effects from increased costs to cruise lines or shipping operations. No effects to ferry operations.	No effects.

32878 ^{1/}“Wet” water years are defined as conditions under the highest 20th percentile forecasted volume at The Dalles
32879 Dam.

32880 **3.10.3.4 Multiple Objective Alternative 2**

32881 Similar to MO1, a number of planned structural measures under MO2, such as installing ‘fish-
32882 friendly’ high efficiency turbines at John Day or adding additional surface passage routes at
32883 specific projects, are unlikely to have measurable impacts to commercial navigation or cruise
32884 lines in the CSNS because they do not affect flow or elevation of water. However, the following
32885 operational measures have the potential to affect operations on the CSNS by altering reservoir
32886 levels and/or the quantity or the timing of the flows in the lower Snake and lower Columbia
32887 River (or both).

32888 *Spill to 110% TDG, Ramping Rates for Safety, and Full Range Reservoir Operations* measures
32889 could alter reservoir levels and/or the quantity or the timing of the flows in the lower Snake
32890 and lower Columbia Rivers (or both), and have the potential to affect operations on the CSNS.

32891 Under MO2, impacts due to operational changes would likely be similar in the short-term
32892 versus the longer-term operation of the system, assuming that the operational changes would
32893 begin while structural measures were implemented.

32894 Commercial ferry operations on Lake Roosevelt have potential to be affected by operational
32895 changes at Grand Coulee that result in lower reservoir levels earlier in the year.

32896 **SOCIAL WELFARE EFFECTS**

32897 **Commercial Navigation and Transportation Systems**

32898 The H&H data used as input into the SCENT model, as presented in Table 3-241., shows that
32899 MO2 would have slightly fewer days in normal and high flow conditions and a greater number
32900 of days in the low category than the No Action Alternative.

32901 **Table 3-241. Changes in Average Commercial Navigation Flow Days Under Multiple Objective**
32902 **Alternative 2 Relative to No Action Alternative, over 50 years**

Number of Days Under Various Flow Condition (Days Per Year)					Number of Days Experiencing Draft Restriction (Days Per Year)					
River Segment	Low	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft
Shallow	3.0	(0.5)	(0.3)	–	–	–	–	–	–	–
Deep Draft	3.0	(0.5)	(0.3)	–	<0.1	–	<0.1	<0.1	0.1	(0.2)

32903 Note: The “Shallow” categories include both the Columbia-Snake Shallow category, which refers to traffic that
32904 traveled on both the Columbia and Snake Rivers, and the Columbia Shallow, which presents the impact to traffic
32905 only traveling on the Columbia.

32906 Source: SCENT modeling

32907 Table 3-242. for Alternative MO2 presents anticipated changes in average annual operating
32908 costs that would occur under MO2. Costs of operations under normal flow range categories
32909 would not be affected under MO2. The impact to shallow-draft traffic equates to a decrease in
32910 average annual costs of approximately \$18,000. However, low flow conditions affect the costs
32911 for deep-draft traffic, which would see an increase of \$178,000. The combination of shallow-
32912 and deep-draft effects would result in an increase in average annual costs to commercial
32913 navigation operations of \$160,000.

32914 **Table 3-242. Changes in Average Annual Costs of Commercial Navigation Operations Under Multiple Objective Alternative 2**
32915 **Relative to No Action Alternative (2019 Dollars), over 50 years**

River Segment	Change in Costs Associated with Flow Range Categories				Changes in Costs Associated with Draft Restrictions						
	Low	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft	Total
Columbia-Snake Shallow	–	-\$8,000	-\$20,000	\$12,000	–	–	–	–	–	–	-\$16,000
Columbia Shallow	–	-\$1,000	-\$4,000	\$2,000	–	–	–	–	–	–	-\$2,000
Deep Draft	\$237,000	-\$17,000	-\$45,000	-\$10,000	\$1,000	–	\$4,000	\$4,000	\$9,000	\$5,000	\$178,000
Total	\$237,000	-\$26,000	-\$69,000	\$4,000	\$1,000	\$0	\$4,000	\$4,000	\$9,000	\$5,000	\$160,000

32916 Note: The Columbia-Snake Shallow category refers to traffic that traveled on both the Columbia and Snake Rivers while the Columbia Shallow presents the
32917 impact to traffic only traveling on the Columbia. These effects are all within one standard deviation of the No Action Alternative conditions. Costs of operations
32918 under normal flow range categories are not anticipated to be affected under any alternatives and are therefore excluded from the table. Numbers may not
32919 sum due to rounding.

32920 Source: SCENT modeling

32921 **Dredging Operations**

32922 Negligible changes to dredging operations would occur under MO2 because anticipated
32923 changes to river flows and stages would not have effects on sediment transport in areas used
32924 by commercial navigation.

32925 **Commercial Cruise Line Operations**

32926 Negligible changes to cruise ship operations would occur under MO2 because anticipated
32927 changes to river flows and stages would not affect timing or use of the navigation channel by
32928 the industry.

32929 **Commercial Ferry Operations**

32930 The H&H modeling data indicate that water surface elevations on Lake Roosevelt would be
32931 sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under
32932 MO2 in average water years as well as in dry water years, similar to the No Action Alternative.
32933 In larger runoff years, the ferry would be inoperable for certain periods when Lake Roosevelt
32934 would be lowered in April and May in order to reduce potential flooding effects downstream. In
32935 these wet years (defined as conditions under the highest 20th percentile forecasted volume at
32936 The Dalles Dam), the Inchelium-Gifford Ferry would not be able to operate for approximately
32937 36 consecutive days in the year under MO2 (or 10 percent of the year in wet years), which
32938 would be 9 days more than under the No Action Alternative (an increase of 33 percent). The
32939 average daily number of passengers on the ferry is 410 (CTCR 2019). At this rate, approximately
32940 3,700 ferry trips could be affected in wet years under MO2. Longer inoperable periods would
32941 be expected in wetter years that require more FRM space.

32942 **REGIONAL ECONOMIC EFFECTS**

32943 **Commercial Navigation and Transportation Systems**

32944 Average annual costs to the navigation industry would increase by approximately \$160,000
32945 under MO2. These effects are not likely to result in noticeable effects to regional economies.

32946 **Commercial Cruise Line Operations**

32947 Negligible effects to commercial cruise line operations would occur under MO2. Given this,
32948 effects to regional economies are not anticipated.

32949 **Commercial Ferry Operations**

32950 As stated above, MO2 would result in a loss of 9 days of operations by the Inchelium-Gifford
32951 Ferry in wet years (a 33 percent change from the No Action Alternative), which could represent
32952 3,700 fewer ferry trips. Longer inoperable periods would be expected in wetter years that
32953 require more FRM space. In those years and for those days, expenditures associated with these
32954 trips via ferry would likely be delayed or would not take place in the same locations.

32955 **OTHER SOCIAL EFFECTS**

32956 **Commercial Navigation and Transportation Systems**

32957 Average annual costs to the navigation industry would increase by approximately \$160,000
32958 under MO2. These effects are not likely to result in noticeable changes to other social effects,
32959 including changes in air emissions.

32960 **Commercial Cruise Line Operations**

32961 Negligible effects to commercial cruise line operations would occur under MO2. Given this,
32962 changes to other social effects are not anticipated under MO2.

32963 **Commercial Ferry Operations**

32964 As stated above, MO2 would result in a loss of an additional 9 days of operations by the
32965 Inchelium-Gifford Ferry in wet years (a 33 percent increase from the No Action Alternative) for
32966 a total of 36 consecutive days when the ferry would not be able to operate. Longer inoperable
32967 periods would be expected in wetter years that require more FRM space, reducing access to
32968 remote communities on the Colville Reservation that use the ferry. Changes in access by the
32969 remote communities during those days would reduce access to healthcare and educational
32970 facilities, in addition to food and shopping resources. Without the ferry, commuters and others
32971 who need to make the trip must take a 70-mile detour, which adds substantial mileage, gas
32972 costs, time, air emissions, and other effects (Spokesman-Review 2017). Since the ferry is free
32973 and reduces driving time and distance, the loss of ferry service would create additional
32974 transportation costs.

32975 **SUMMARY OF EFFECTS**

32976 MO2 would result in negligible increases in average annual costs for deep-draft navigation and
32977 a minor decrease in costs for shallow-draft navigation. The increase in costs for deep-draft
32978 navigation would result from additional days of low flows, which would require an increase in
32979 the number of tug operations. Overall, this would represent a change in average annual costs of
32980 \$160,000 to the industry, representing a negligible (less than 0.1 percent) increase in costs in
32981 comparison to the No Action Alternative. Effects to the cruise line industry would be negligible.

32982 Moderate effects would occur to the Inchelium-Gifford Ferry, as while no effects on ferry
32983 operations would occur in normal or dry water years, in wet years, the ferry could operate 9
32984 days fewer under MO2 than under the No Action Alternative in wet years (for a total of 36
32985 consecutive days when the ferry would not operate annually), which could represent 3,700
32986 fewer ferry trips. During those years minor social welfare effects could be experienced due to
32987 the longer inoperable period. Minor effects due to loss or redistribution of expenditures
32988 associated with the ferry trips could also occur. Changes in access to healthcare and
32989 educational facilities, in addition to food and shopping resources, could result in moderate
32990 adverse effects. Other ferries would not be affected under MO2.

32991 Table 3-243. provides a summary of the navigation and transportation system effects of MO2.

32992 **Table 3-243. Changes in Economic Effects of Navigation and Transportation Under Multiple**
32993 **Objective Alternative 2 Relative to the No Action Alternative, over 50 years**

Region	Social Welfare Effects	Regional Economic Effects	OSE
Region B	Minor effect due to decrease in Inchelium-Gifford Ferry operations of an additional 9 days in wet years (for a total of 36 consecutive days). ^{1/} Longer inoperable periods would be expected in wetter years that require more FRM space.	Minor impact due to loss or redistribution of expenditures associated with approximately 3,700 Inchelium-Gifford Ferry trips in wet years. Longer inoperable periods would be expected in wetter years that require more FRM space.	Moderate impact due to reduced access to healthcare and other services of the Inchelium-Gifford for 9 fewer days in wet years for a total inoperable period of 36 consecutive days annually. Longer inoperable periods would be expected in wetter years that require more FRM space.
Region C (Snake Shallow)	Negligible effects anticipated to commercial navigation or commercial cruise lines. Average annual cost increases represent less than 0.1 percent of total costs of navigation operations.	Negligible effects from increased costs to cruise lines or shipping operations. Negligible effects to port operations.	No effects.
Region D (Columbia Shallow)	Negligible effects anticipated to commercial navigation or commercial cruise lines. Average annual cost increases represent less than 0.1 percent of total costs of navigation operations.	Negligible effects from increased costs to cruise lines or shipping operations. Negligible effects to port operations.	No effects.
Region D (Deep Draft)	Negligible effects anticipated. Average annual cost increases represent less than 0.1 percent of total costs of navigation operations. No effects to ferries.	Negligible effects from increased costs to cruise lines or shipping operations. No effects to ferry operations.	No effects.

32994 1/“Wet” water years are defined as conditions under the highest 20th percentile forecasted volume at The Dalles
32995 Dam.

32996 **3.10.3.5 Multiple Objective Alternative 3**

32997 The primary structural change in MO3 is the *Breach Snake Embankments* measure, which
32998 removes the earthen embankment portions of four projects located on the lower Snake River:
32999 Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. This measure would result in
33000 substantial effects by curtailing commercial navigation on the Snake River beyond Ice Harbor.
33001 The Columbia River shallow-draft channel would still be operable; however, access to the
33002 shallow-draft channel from certain port facilities at the confluence of the Snake with the
33003 Columbia and within the McNary Reservoir would require additional dredging.

33004 Along with breaching the four lower Snake River dams, MO3 includes some operational
33005 measures that also have the potential to affect operations on the Columbia shallow- and deep-

33006 draft channels. The *Spring Spill to 120% TDG, Ramping Rates for Safety, and John Day Full Pool*
33007 measures would alter reservoir levels or the quantity or the timing of the flows in the lower
33008 Columbia River (or both), and therefore, have the potential to result in major effects in how
33009 vessels move on the CSNS. A number of planned structural measures, such as modifying
33010 existing fish passage systems, would have no effects to commercial navigation or cruise lines in
33011 the CSNS because they do not affect flow or elevation of water.

33012 **SOCIAL WELFARE EFFECTS**

33013 **Commercial Navigation and Transportation Systems**

33014 The transportation model developed to measure the impact of alternative river navigation
33015 scenarios under MO3 is a constrained optimization model designed to capture the choices
33016 currently facing shippers that use the Columbia-Snake River System, particularly the navigable
33017 portions of the lower Snake River. According to the lock reports maintained by the Corps, the
33018 commodities shipped on the system are predominantly grain (wheat and barley) for downriver
33019 barge movements and fuel for upriver shipments. There are a variety of other commodities
33020 moved in smaller volumes, but grain (wheat and barley) comprises the majority (more than 87
33021 percent in 2018) of the downbound tonnage moved on the lower Snake River and 62 percent of
33022 overall tonnage on the lower Snake River. The model captures the choices faced by shippers
33023 moving these products to market. Generally, data compiled from a variety of sources provides
33024 the necessary information to parameterize the model and establish the constraints and choice
33025 alternatives, representing current conditions, as they exist. Fuel comprises the majority of
33026 upbound tonnage on the lower Snake River (91 percent in 2018), most of which terminates
33027 river passage above Pasco, Washington. Fuel comprises 27 percent of overall tonnage on the
33028 lower Snake River. Fuel movements are not modeled due to data limitations and uncertainty of
33029 how movements may be affected under MO3. The Columbia River shallow-draft channel would
33030 still be operable; however, access to the shallow-draft channel from certain port facilities at the
33031 confluence of the Snake with the Columbia and within the McNary Pool would require
33032 additional dredging. However, given the safety concerns associated with fuel movements, it is
33033 unclear if fuel companies would continue movements in the McNary Pool to Pasco,
33034 Washington.

33035 Additional details on the data and model parameterization are available in Appendix L,
33036 *Navigation*.

33037 Evaluating the impact of removing the lower Snake River locks and barge navigation above
33038 Pasco, Washington, is completed by modifying the transportation optimization model by not
33039 allowing shipments on river terminals along the lower Snake River.¹⁰ It is likely that the facilities
33040 with rail access would continue to be used to some extent for storage and transport via rail or

¹⁰ Currently, modeling assumes that ports on the Columbia River above McNary Dam as well as the two facilities at the mouth of the Snake River would remain operational (in particular, Pasco and Kennewick). However, modeling indicates that some facilities on the Columbia River above McNary Dam may also experience interruptions in service if dredging to access these ports is not conducted under MO3. This is discussed in the Dredging Operations portion of Section 3.10.3.5.

33041 truck; however, these facilities are assumed to be closed for purposes of this analysis. To the
33042 extent that some terminals on the lower Snake River could continue to be used, the effects to
33043 shippers would be lower than model results suggest. Economic impacts on shippers would be
33044 most acute in the short term, as shippers, ports, port services and related companies have
33045 invested in equipment and labor that is suited to current conditions. As the industry adapts
33046 over time, more rail capacity and associated storage would likely be added in the region to
33047 accommodate freight affected by loss of river navigation on the lower Snake River. In addition,
33048 highways would be utilized more heavily. Ports have commented that the availability of land at
33049 port sites may constrain their ability to add rail capacity, as well as the time-intensive and
33050 uncertain permitting process to augment rail capacity (Port of Lewiston 2019).

33051 Rail price increases are constrained by the market. By removing the option of shipment via barge,
33052 prices on the rail lines are likely to increase. As described in the following sections, three
33053 scenarios are considered for understanding potential effects of MO3: Scenario 1 assumes rail
33054 rates would not increase; Scenario 2 assumes rail rates would increase by 25 percent regionwide;
33055 and Scenario 3 assumes the rail rates would increase by 50 percent regionwide. Some
33056 stakeholders have stated their opinion that a 50 percent rail rate increase seems too low because
33057 railroads would take advantage of monopolistic pricing opportunities absent an operational
33058 Snake River channel as an alternative (e.g., Idaho Cooperating Agencies 2019). However, others
33059 agree with the assessment that 50 percent is likely to be a reasonable upper-bound estimate. As
33060 shown in the modeling results below, an increase of 50 percent in rail rates would be high
33061 enough to entice shipping volume back to barge movements at the Tri-Cities, and would
33062 therefore be likely to constrain increases higher than 50 percent. At the highest end, rail prices
33063 would be constrained by costs to ship via truck, which is generally the most expensive option.
33064 Some commenters have expressed concern that because rail is privately owned, it is less reliably
33065 available than the river system (e.g., Idaho Cooperating Agencies 2019). Shippers have expressed
33066 some concern that private decisions related to making train cars available based on prices of
33067 other commodities would also affect the reliability of the rail lines for supplying adequate
33068 capacity to serve the shipping needs (Port of Lewiston and shippers 2019). Commenters have
33069 further stated it is difficult to secure a unit train on short notice to take advantages of seasonal
33070 demand (Idaho Cooperating Agencies 2019).

33071 The modeling scenarios presented below are used to capture a reasonable range of effects on
33072 commodity movements and transportation costs, given the range of uncertainties surrounding
33073 how rates may change if the lower Snake River navigation channel is no longer available. Along
33074 with how movements and transportation costs would change, potential effects on infrastructure
33075 and the improvements that would be needed are described.

33076 ***Scenario 1: Effects of Dam Breach on Grain Transportation Assuming Constant Rail Rate***

33077 Under Scenario 1, commodities that would have been transported on the lower Snake River are
33078 assumed to be transported using the next least cost alternative. Costs of alternative shipping
33079 modes, including rail, are assumed not to change under this scenario. This scenario is likely to
33080 be a low estimate, as rail rates are likely to increase following dam breach. However, this
33081 scenario would also lead to the highest increase in rail usage because of the relative cost of rail
33082 compared to truck and/or truck and barge. As such, it captures the largest increase in demand

33083 for rail that could be expected under any scenario. In this way, it identifies the upper bound of
33084 potential demands on rail and rail infrastructure.

33085 Scenario 1 is heavily dependent on two assumptions. First, the scenario assumes that existing
33086 shuttle rail facilities would be able to accommodate with some limited expansion for most of
33087 the grain that otherwise would have used the lower Snake River ports (slightly more than
33088 double existing shuttle rail facility volumes). This assumption appears as a reasonable starting
33089 point because shippers have reported that shuttle rail facilities can accommodate up to 25
33090 million bushels per year with some storage adjustments, which is equivalent to 0.75 million
33091 tons per facility (Idaho Cooperating Agencies 2019). As such, total capacity of these facilities
33092 would be approximately 3 million tons, which is more than the total grain volume on the river
33093 in recent years. Second, the model assumes that the shortline railroads would be able to
33094 accommodate increased volumes going to shuttle rail facilities. It appears likely that
33095 improvements to the shortline rail lines would be required to accommodate this increased
33096 volume. Potential costs associated with required shortline rail improvements are discussed in
33097 the Regional Economic Effects section, below. In addition, ports have commented that because
33098 grain does not move at the same export volume throughout the year, but rather is dependent
33099 on world demand, issues could exist in providing adequate rail capacity at critical times (Port of
33100 Lewiston 2019).

33101 Under Scenario 1, the total costs to transport grain to market would increase by 10 percent
33102 from \$145 million to \$159 million, representing an increase of \$14 million, or approximately 7
33103 cents per bushel. The cost increases to specific shippers would depend upon location and vary
33104 throughout the region, depending on transportation options at each location. Generally, those
33105 grain shippers that are the furthest from alternate shipping locations (shuttle rail facilities or
33106 river ports on the Columbia River) would be the most negatively impacted. Note, cost scenarios
33107 for specific farmers are presented below in the Regional Economic Effects section.

33108 The primary reason that the transportation costs would not increase more dramatically under
33109 Scenario 1 is the assumed availability of the four shuttle rail facilities to absorb these shipments
33110 (in Ritzfield, Washington [Templin Facility], and Four Lakes, Washington [High Line Facility], 2
33111 hours from Pasco, Washington, via highway; in Rosalia, Washington [McCoy Facility], south of
33112 Spokane and 2.5 hours from Pasco, Washington; and a new facility in Lacrosse, Washington
33113 [Endicott Facility], which is located closest to the Snake River and 1.5 hours from Pasco,
33114 Washington). As discussed above, each facility currently has approximately 25 million bushels
33115 of capacity, or the ability to handle 0.75 million tons per year, or 3 million tons across all of the
33116 facilities. Under MO3 Scenario 1, the total shuttle rail freight volume would almost double from
33117 current volumes, increasing from 71 million bushels under the No Action Alternative to 138
33118 million bushels under Scenario 1. This would represent a substantial increase in shuttle rail
33119 volume that would exceed current shuttle rail capacities of 100 million bushels. As such,
33120 increased capacity would be needed at the four currently operating shuttle rail facilities under
33121 Scenario 1. Due to this required increased in capacity, it would seem that this increase would be
33122 unlikely to occur without an associated increase in rail rates. The majority of the increase in
33123 grain shipments by shuttle rail would arrive from other grain elevators with rail via rail, as
33124 opposed to truck shipments on highways. The analysis assumes that shortline railroads would
33125 be primarily responsible for this in rail volume increase; however, uncertainty exists about

33126 whether shortline railroads would be able to adjust operations and/or facilities to
33127 accommodate the increase in volume.

33128 Given that the Snake River ports would be no longer accessible, the aggregate amount of grain
33129 coming directly from farms to river ports would decrease under Scenario 1. The total grain
33130 volume accessing any river port along the CSNS, moving directly from farm to river ports via
33131 truck at or below Pasco, Washington, would decrease from 125 to 45 million bushels (a
33132 decrease of 64 percent), while the average distance of truck trips for those shipments would
33133 increase from 39 to 48 miles (an increase of 22 percent relative to the No Action Alternative).

33134 Columbia River barge transportation would continue to be important in the region downstream
33135 of Pasco under MO3, representing 32 percent of all grain moving to export (compared to 65
33136 percent under the No Action Alternative). Grain transported on the river is assumed to arrive
33137 via truck.

33138 The total impacts to transportation infrastructure (measured in ton-miles) would increase from
33139 2.37 to 2.47 billion ton-miles, an increase of 96 million ton-miles, under MO3 Scenario 1
33140 (representing an increase of 4.1 percent compared with the No Action Alternative). Highway
33141 (truck) ton-miles would increase from 464 million to 551 million, while barge ton-miles would
33142 decrease from 1.09 billion to 391 million on the CSNS.

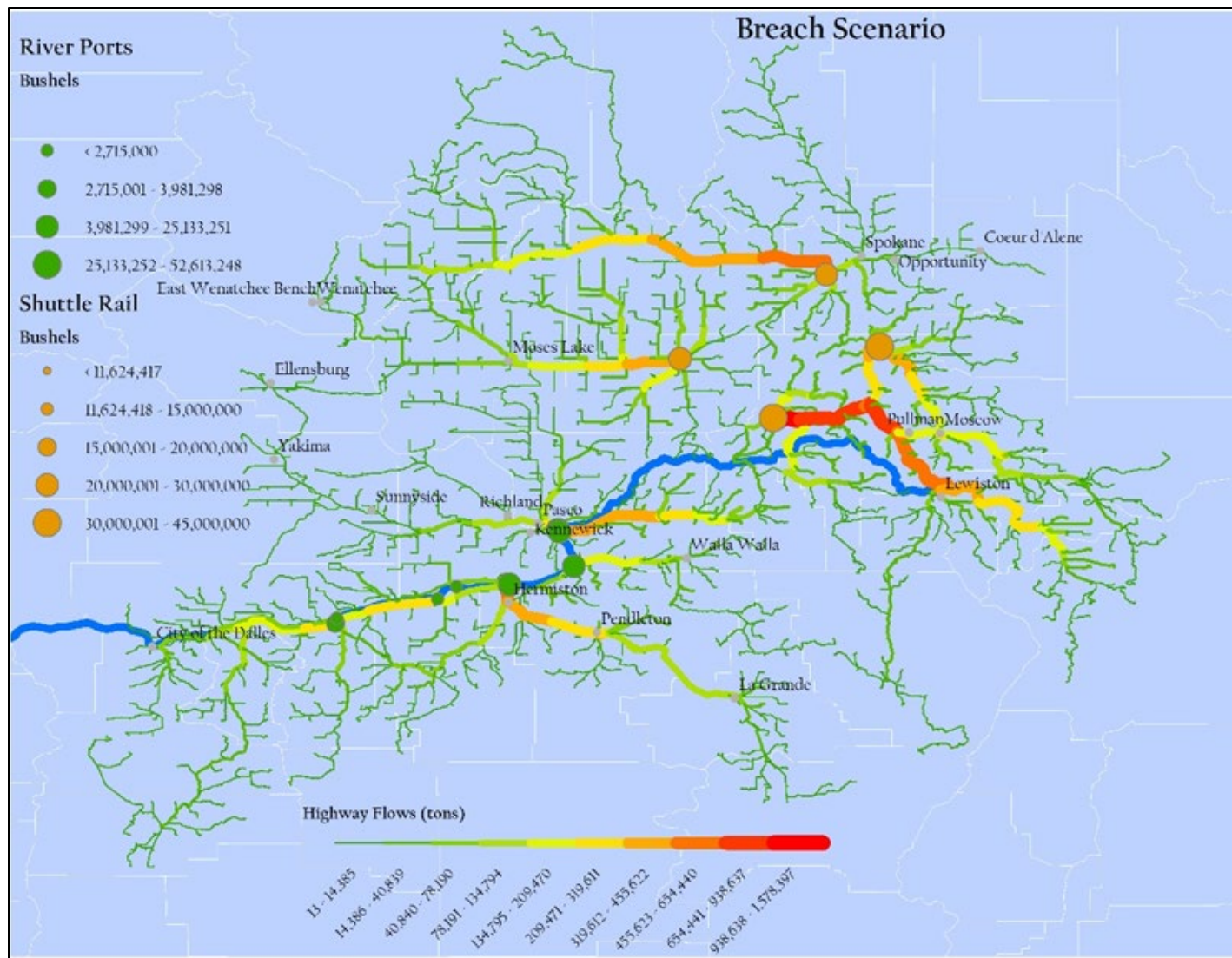
33143 Under Scenario 1, the decreasing barge volume could adversely affect companies that
33144 particularly depend on this transit mode, such as tow boat companies. The increase in highway
33145 ton-miles is primarily due to grain shippers moving commodities to rail shuttle facilities and also
33146 to commodities being trucked farther to river ports on the middle Columbia, below the closure,
33147 than would be anticipated under the No Action Alternative.

33148 Assuming constant rail rates, railroad ton-miles would increase the most under Scenario 1 (No
33149 Rail Rate Increase), increasing from 819 million ton-miles under the No Action Alternative to 1.5
33150 billion ton-miles under MO3. This would include a substantial increase in volume at each of the
33151 four shuttle rail facilities, particularly for the Lacrosse facility given its close proximity to the
33152 river and the fact that it would be the most likely alternative for production impacted by river
33153 closure. This increase would represent an increase in the number of unit trains (with
33154 approximately 110 cars per train) from approximately four trains to approximately eight trains
33155 per month at each shuttle rail facility. Overall, the annual number of shuttle rail unit train trips
33156 in the region would increase by 185, and the number of shuttle rail cars loaded would increase
33157 by over 20,000. This would represent an increase of 94 percent over current shuttle rail activity.

33158 A summary of the changes in grain flows, transportation costs, and ton-miles under the MO3
33159 Scenario 1 are provided in Table 3-244.. Figure 3-212 depicts shipping patterns by mode for
33160 grain shippers under MO3 Scenario 1. Specifically, the figure illustrates the highway flows of
33161 grain shipments, the location of origination points used in the transportation optimization
33162 model, river port terminals along the Columbia-Snake navigation channel (green circles) and
33163 shuttle rail terminals (orange circles). Once the lower Snake River ports are eliminated in this
33164 scenario, the shuttle rail facilities accommodate the majority of grain displaced from the lower
33165 Snake River terminals. Given this, the intensity of highway flows changes and the thickness of
33166 lines (highways) accessing the shuttle rail terminals increases substantially under this scenario.

33167 **Table 3-244. Multiple Objective Alternative 3 Scenario 1 (No Rail Rate Increase): Changes from No Action Alternative**

Origin-Destination Type	Mode	Volume (bushels)	Total Cost	Cents/Bushel	Ton-Miles	Average Distance (miles one direction)
Farm to Elevator (no rail)	Truck	892,106	\$153,501	(0.02)	716,451.02	-6.2
Farm to Elevator (with rail)	Truck	32,495,497	\$6,697,210	(0.01)	44,975,116.60	-3.0
Farm to Elevator (shuttle rail)	Truck	46,638,258	\$17,585,877	0.07	198,778,387.35	18.2
Farm to River Port	Truck	(80,025,861)	(\$20,611,512)	0.03	180,552,934.00)	8.7
Elevator to Elevator with Rail	Truck	498,298	\$111,709	0.22	845,211.88	25.7
Elevator to Elevator Shuttle Rail	Truck	–	\$0	-	-	0.0
Elevator to River Port	Truck	393,808	\$98,164	(0.01)	834,742.44	-1.8
Elevator with Rail to Shuttle Rail	Truck	–	\$0	-	-	0.0
Elevator with Rail to Shuttle Rail	Rail	20,370,770	\$3,616,605	(0.04)	26,371,415.15	-18.9
Elevator with Rail to River Port	Truck	12,623,025	\$2,830,615	(0.06)	21,368,106.49	-14.3
Elevator with Rail to River Port	Rail	–	\$0	-	-	0.0
Shuttle Rail Elevator to Portland	Rail	67,009,028	\$33,288,202	(0.01)	678,577,651.95	-14.8
River Port to Portland	Barge	(67,009,028)	(\$29,907,142)	(0.05)	695,534,049.16)	-73.0
Total Change from NAA		–	\$13,863,228	\$0.07	(96,380,100)	–



33168
 33169
 33170

Figure 3-212. Multiple Objective Alternative 3 Scenario 1: Shipping Routes by Mode
 Source: Transportation optimization model, parameterized to reflect current conditions.

33171 **Scenario 2: Effects of Dam Breach on Grain Transportation Assuming Rail Rate Increase of 25**
33172 **Percent**

33173 Unlike Scenario 1, Scenario 2 assumes that rail rates would increase by 25 percent above the No
33174 Action Alternative rates. Increasing rail rates by 25 and then 50 percent (Scenario 3) allow for
33175 improved understanding of modal shift and pricing sensitivity between rail and river transport.
33176 As under MO3 Scenario 1, the cost increase to specific shippers would depend upon location
33177 and would vary throughout the region, depending on transportation options at each location.
33178 Generally, those grain shippers that are the farthest from alternative shipping locations (shuttle
33179 rail facilities or river ports on the Columbia River) would be the most negatively impacted.

33180 Increasing rail rates by 25 percent in Scenario 2 would result in a total cost of \$176 million, a
33181 \$31 million (22 percent) increase in costs (in comparison to the \$13 million increase under
33182 Scenario 1), and is equivalent to an average transportation cost of 87 cents per bushel. A
33183 transportation cost of 87 cents per bushel equates to an increase of 15 cents from the No
33184 Action Alternative (a percentage increase of 22). Some individual shippers may experience
33185 increases that are more than double this amount, depending on their location.

33186 The distribution of volume moving via different transportation modes would change
33187 substantially under this scenario, as the increase in rail rates would shift grain shipments away
33188 from shuttle rail lines to a combination of truck and barge. In Scenario 2, the total volume
33189 moving by shuttle rail to export ports would be 120 million bushels, a 67 percent increase from
33190 the No Action Alternative and a decrease of 14 percent from Scenario 1. The total volume
33191 moving by barge, 83 million bushels, decreases from the No Action Alternative estimate of 131
33192 million (a decrease of 37 percent) and increases from the Scenario 1 estimate of 64 million (an
33193 increase of 29 percent). Note, river ports still operating on the Columbia River at Pasco,
33194 Washington, would experience a large volume increase, mostly from shipments arriving via
33195 truck traveling longer distances to access the river ports.

33196 Total ton-miles under Scenario 2 would increase from the No Action Alternative to 2.46 billion
33197 (an increase of 93 million compared to the No Action Alternative). In this scenario, barge ton-
33198 miles would substantially decrease from the No Action Alternative to 517 million while both
33199 truck and rail would increase from the No Action Alternative to 613 million and 1.33 billion ton-
33200 miles, respectfully. As in Scenario 1, this modal change would create a substantial increase in
33201 volume at each of the four shuttle rail facilities. Under Scenario 2, this increase would represent
33202 an increase in the number of unit trains (with approximately 110 cars per train) from
33203 approximately four trains to approximately seven trains per month at each shuttle rail facility.
33204 Overall, the annual number of shuttle rail unit train trips in the region would increase by 133,
33205 and the number of shuttle rail cars loaded would increase by over 15,000. This would represent
33206 an increase of 35 percent over current shuttle rail activity.

33207 The changes in grain flows, transportation costs, and ton-miles under MO3 under Scenario 2
33208 are summarized in Table 3-245. Figure 3-213 provides a visual depiction of commodity
33209 movements by mode for Scenario 2. As in Table 3-245, Figure 3-213 depicts shipping patterns
33210 by mode for grain shippers under MO3, Scenario 2. Specifically, the figure illustrates the

33211 highway flows of grain shipments, the location of origination points used in the transportation
33212 optimization model, river port terminals along the Columbia-Snake navigation channel (green
33213 circles) and shuttle rail terminals (orange circles). As shown, when rail rates assumed to
33214 increase by 25 percent after the breach, a larger proportion of the grain is now trucked to the
33215 Tri-Cities area, as indicated by the thick, orange-red lines in Figure 3-213.

33216 **Table 3-245. Multiple Objective Alternative 3 Scenario 2 (25 percent Rail Rate Increase):**
33217 **Changes from No Action Alternative**

Origin-Destination Type	Mode	Volume (bushels)	Total Cost	Cents/Bushel	Ton-Miles	Average Distance (miles)
Farm to Elevator (no rail)	Truck	4,201,670	\$885,508	(0.02)	6,153,442.72	-4.5
Farm to Elevator (with rail)	Truck	44,722,739	\$9,534,917	(0.01)	67,287,654.97	-2.1
Farm to Elevator (shuttle rail)	Truck	31,101,452	\$12,077,649	0.06	138,459,240.10	15.2
Farm to River Port	Truck	(80,025,861)	-\$19,069,260	0.07	(154,741,874.54)	17.3
Elevator to Elevator with Rail	Truck	498,298	\$111,709	0.22	845,211.88	25.7
Elevator to Elevator Shuttle Rail	Truck	-	\$0	-	-	0.0
Elevator to River Port	Truck	3,703,372	\$2,258,162	0.24	29,984,454.23	59.6
Elevator with Rail to Shuttle Rail	Truck	-	\$0	-	-	0.0
Elevator with Rail to Shuttle Rail	Rail	17,173,661	\$2,740,914	(0.05)	17,608,509.41	-22.7
Elevator with Rail to River Port	Truck	28,047,376	\$7,123,924	(0.04)	61,478,081.62	-10.2
Elevator with Rail to River Port	Rail	-	\$0	-	-	0.0
Shuttle Rail Elevator to Portland	Rail	48,275,113	\$38,784,812	0.12	495,088,604.69	-10.6
River Port to Portland	Barge	(48,275,113)	-\$23,202,569	(0.05)	(568,883,879.43)	-68.0
Total Change from NAA		-	\$31,245,767	0.15	93,279,446	-

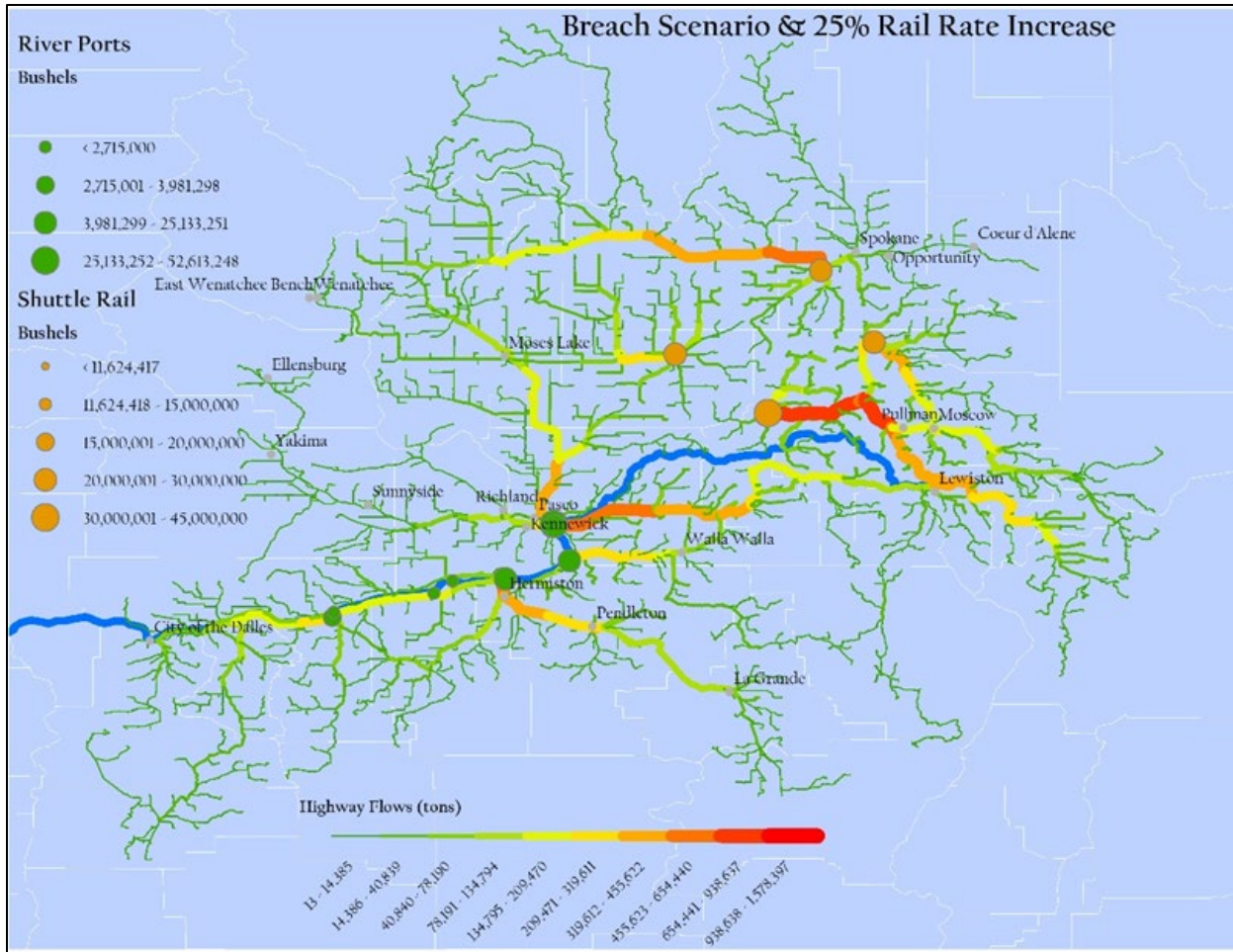


Figure 3-213. Multiple Objective Alternative 3 Scenario 2 (25 Percent Rail Rate Increase): Shipping Routes by Mode

Source: Transportation optimization model, parameterized to reflect current conditions.

Scenario 3: Effects of Dam Breach on Grain Transportation Assuming Rail Rate Increase of 50 Percent

Under Scenario 3, like in Scenario 1 and 2, it is assumed commodities that would have been transported on the lower Snake River under the No Action Alternative using the next least cost alternative. However, Scenario 3 assumes that rail rates would increase by 50 percent above No Action Alternative rates. As discussed above, rail rates increased between 35 and 40 percent during periods in the past when the lower Snake River navigation was closed due to lock maintenance. Those closures were temporary and planned (announced) and shippers adjusted volumes accordingly. Given this, increases in rail rates from a permanent closure would likely be higher given that the competitive pressure between two competing modes would no longer exist and the rail industry could exercise monopoly pricing. Therefore, this scenario represents a reasonable high estimate. As under Scenario 1 and Scenario 2, the cost increase to specific shippers would depend upon location and would vary throughout the region, depending on transportation options at each location. Generally, those grain shippers that are the farthest from alternative shipping locations (shuttle rail facilities or river ports on the Columbia River)

33237 would be the most negatively impacted. The Regional Economic Effects section describes
33238 farming effects in more detail.

33239 Increasing rail rates by 50 percent in Scenario 3 under MO3 would result in total transportation
33240 costs of approximately \$193 million, a \$48 million increase in costs (in comparison to the \$13
33241 million increase under Scenario 1 and to the \$31 million increase under Scenario 2), and is
33242 equivalent to 95 cents per bushel transportation costs. This would represent a 24 cent per
33243 bushel increase from the No Action Alternative (an increase of 33 percent when compared with
33244 the No Action Alternative). While this increase would represent an increase of 33 percent on
33245 average, some individual shippers may experience increases that are more than double this
33246 amount, depending on their location.

33247 The TOM model finds that the distribution of volume moving via different transportation
33248 modes would change substantially under this scenario, as the increase in rail rates would
33249 dramatically shift grain shipments away from shuttle rail lines. Instead shippers would move
33250 grain either by rail to river terminals on the Columbia River, or by truck to river terminals on the
33251 Columbia River. The total volume moving by shuttle rail to export ports would increase under
33252 Scenario 3 to 72 million bushels, which is a 1.1 percent increase compared to the No Action
33253 Alternative. The volume moving by barge (130 million bushels) would be higher than under
33254 Scenario 1 (64 million bushels), and would be slightly lower than would have occurred under
33255 the No Action Alternative (131 million bushels), representing a decrease of 0.6 percent. River
33256 ports still operating on the Columbia River at Pasco, Washington, would experience a large
33257 volume increase, mostly from shipments arriving via truck traveling longer distances to access
33258 the river ports.¹¹

33259 Total ton-miles under Scenario 3 would increase to 2.5 billion, a 5 percent increase from the No
33260 Action Alternative. Total truck ton-miles would increase dramatically to 855 million ton-miles
33261 (391 million more than under the No Action Alternative). Under MO3 Scenario 3, there would
33262 be a 33 percent increase in total transportation cost regionwide. However, some shippers may
33263 experience increases that are more than double this amount, depending on location (refer to
33264 the Regional Economic Effects section for a discussion of costs to agricultural operations).
33265 Unlike Scenarios 1 and 2, modal changes under Scenario 3 would only create a small increase in
33266 volume at each of the four shuttle rail facilities. Consistent with the No Action Alternative, each
33267 shuttle rail facility would receive approximately four trains per month. Overall, the annual
33268 number of shuttle rail unit train trips in the region would increase by two, and the number of
33269 shuttle rail cars loaded would increase by approximately 240. This would represent a less than 1
33270 percent change from current shuttle rail activity.

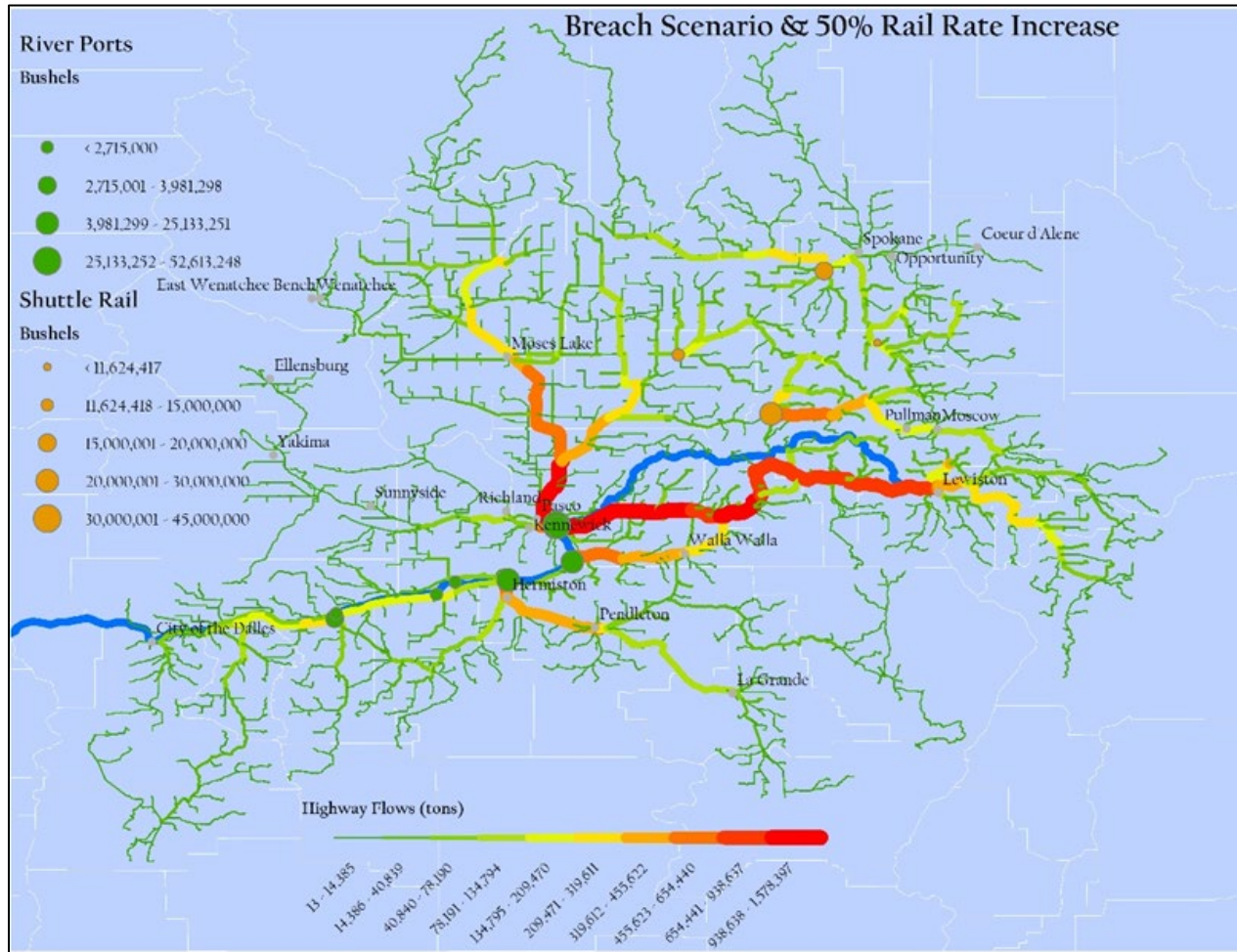
¹¹ The model assumes that after freight is loaded onto rail lines, it is shipped to Portland via rail and will not be transferred to the river at Pasco or downriver. Should this option be made available, costs would be somewhat lower under this scenario.

33271 The changes in grain flows, transportation costs, and ton-miles under the MO3 under Scenario
 33272 3 are summarized in Table 3-246.. Figure 3-2148 provides a visual depiction of commodity
 33273 movements by mode for Scenario 3. As in Table 3-246., Figure 3-214 depicts shipping patterns
 33274 by mode for grain shippers under MO3, Scenario 3. Specifically, the figure illustrates the
 33275 highway flows of grain shipments, the location of origination points used in the transportation
 33276 optimization model, river port terminals along the Columbia-Snake navigation channel (green
 33277 circles) and shuttle rail terminals (orange circles). As shown, when rail rates assumed to
 33278 increase by 50 percent after the breach, a larger proportion of the grain is now trucked to the
 33279 Tri-Cities area, as indicated by the thick, dark red lines in Figure 3-214.

33280 **Table 3-246. Multiple Objective Alternative 3 Scenario 3 (50 Percent Rail Rate Increase):**
 33281 **Changes from No Action Alternative**

Origin-Destination Type	Mode	Volume (bushels)	Total Cost	Cents/Bushe l	Ton-Miles	Average Distance (miles)
Farm to Elevator (no rail)	Truck	20,240,269	\$3,444,821	(0.06)	15,603,792	-15.4
Farm to Elevator (with rail)	Truck	82,323,807	\$16,164,634	(0.02)	100,240,187	-5.9
Farm to Elevator (shuttle rail)	Truck	(22,538,215)	(\$4,820,439)	0.00	(34,183,387)	0.5
Farm to River Port	Truck	(80,025,861)	(\$14,837,301)	0.16	(84,516,494)	40.9
Elevator to Elevator with Rail	Truck	-	\$0	-	-	0.0
Elevator to Elevator Shuttle Rail	Truck	1,212,417	\$352,402	-	3,425,139	42.8
Elevator to River Port	Truck	19,027,852	\$13,235,305	0.39	181,101,543	96.7
Elevator with Rail to Shuttle Rail	Truck	-	\$0	-	-	0.0
Elevator with Rail to Shuttle Rail	Rail	22,101,943	\$2,513,352	(0.24)	6,037,253	-40.8
Elevator with Rail to River Port	Truck	60,221,864	\$19,928,589	0.03	209,794,207	7.1
Elevator with Rail to River Port	Rail	-	\$0	-	-	0.0

Origin-Destination Type	Mode	Volume (bushels)	Total Cost	Cents/Bushel	Ton-Miles	Average Distance (miles)
Shuttle Rail Elevator to Portland	Rail	776,145	\$17,944,821	0.24	(20,703,326)	-13.5
River Port to Portland	Barge	(776,145)	(\$6,180,280)	(0.05)	(247,902,414)	-61.8
Total Change from NAA		-	\$47,745,902	\$0.24	128,896,500	-



33282
33283 **Figure 3-214. Multiple Objective Alternative 3, Scenario 3 (50 Percent Rail Rate Increase):**
33284 **Shipping Routes by Mode**

33285 **Effects on Other Commodities**

33286 As described above, the modeling effort associated with increased costs to transport goods
33287 focused on grain shippers because these shipments comprise the majority (more than 87
33288 percent) of downriver shipments. However, it is worth noting that other commodities shipped
33289 on the system would also not be able to utilize the system following dam breach. The total

33290 volume of these commodities is relatively small; however, the system provides some unique
33291 services associated with these commodities.

33292 Wood Chips

33293 Wood chips travel both upriver and down river in relatively small volumes in service of
33294 papermills that are located on or near the lower Snake River. As described in Section 3.10.2,
33295 *Affected Environment*, a papermill in Lewiston receives regular shipments of wood chips that
33296 are used as a process input. While comprising a small overall volume, there would be increased
33297 costs to this industry under MO3 associated with shipping these inputs by other means (likely
33298 via truck).

33299 Fuel/Petroleum Products

33300 Primarily an upriver movement that ends above McNary Dam, petroleum products travel via
33301 barge in the shallow system and comprise the primary upbound commodity on the lower Snake
33302 River segment (100 million tons in 2018) (Waterborne Commerce 2020). Because these
33303 shipments currently terminate below Ice Harbor Dam and do not utilize the river channel, they
33304 would not be directly affected by dam removal. However, barge companies report that these
33305 shippers are very sensitive to increased risk and are concerned that potential needs for
33306 dredging facilities in the McNary pool would discourage those shippers from utilizing the
33307 system even if it continues to be made available by periodic dredging (Shaver Transportation
33308 Company 2020).

33309 Shipments of Oversized Objects

33310 As described in the introduction to this section, the CSNS provides a unique water route to
33311 transport oversized cargo into the interior of the United States. Cargo transported upriver to
33312 the Port of Lewiston can then be transported on U.S. Highway 12, which has no cargo height
33313 restrictions. U.S. Highway 12 has no overpasses and similarly there are routes in Montana that
33314 have no height restrictions (Idaho Cooperating Agencies, January 2020). While the system
33315 transports shipments of this type infrequently, it is a unique service that could not be replaced
33316 by road or rail alone.

33317 ***Effects of Flow Changes Other than Breach (SCENT Results)***

33318 Similar to MO1, MO2, and MO4, the SCENT model, which captures how changes in flow days
33319 affects commercial navigation costs, was used to evaluate effects of MO3. Effects of MO3
33320 related to flow changes outside of the lower Snake River were negligible, resulting in an
33321 increase in non-normal flow days of less than 0.1 day. These flow changes would result in
33322 decreases in costs of shallow-draft and deep-draft commercial navigation of approximately
33323 \$31,000 and \$186,000 in average annual costs, respectively. The combination of shallow- and
33324 deep-draft effects results in a decrease in average annual costs to commercial navigation
33325 operations of \$217,000. These effects are all within one standard deviation of the No Action
33326 Alternative conditions.

33327 **Dredging Operations**

33328 As described in Section 3.10.3.5, *River Mechanics*, and in Appendix C, *River Mechanics*, under
33329 MO3 there would be an increased amount of sediment passing from the lower Snake River into
33330 the Columbia River. The MO3 construction period is estimated to be 2 years, beginning with
33331 breaching and drawdown of the upper two projects occurring during the first construction year,
33332 and breaching and drawdowns of the lower two Snake River projects during the second year.
33333 Modeling indicates that sediment volumes and concentrations passing out of the lower Snake
33334 River would be elevated immediately following drawdown, and for the two years that follow as
33335 the system transitions from reservoirs to run of river. After the near-term period, sediment
33336 modeling indicates that there would be an estimated period of 2 to 7 years where lower Snake
33337 River would continue moving higher volumes of sediment, establishing a new dynamic
33338 equilibrium. Over the long term the lower Snake River is expected to eventually reach a new
33339 quasi-equilibrium condition and largely pass incoming sediment loads.

33340 Based upon these changing sediment patterns and timing, dredging operations within the
33341 McNary pool (Wallulla Reservoir) and at the confluence of the lower Snake River would increase
33342 substantially, especially during and directly following dam breaching (between years 2 and 7
33343 post dam breach).¹² Sediment relocation and deposition is expected to occur within the Federal
33344 navigation channel and on the left bank of Lake Wallulla. Additional dredging by the Corps
33345 would be required to maintain the Federal navigation channel. Likewise, public and private port
33346 facilities both near the confluence of the lower Snake River and on the left bank of Lake Wallulla
33347 would be required to dredge in order to avoid interruptions in service and maintain access to
33348 the navigation channel. Estimated dredging costs for maintaining the Federal navigation
33349 channel would be a Corps' expense, while dredging costs to maintain port facilities and access
33350 to the Federal navigation channel would be a local municipalities and/or private business cost.

33351 Dredging estimates were developed for the McNary pool based on the river mechanics analysis
33352 results. The first year post dam breach, it is estimated that 3.8 MCY would be dredged to
33353 maintain the Federal navigation channel, followed by 1.9 MCY annually for the next 3 years
33354 (years 3 through 6 post dam breach). As described above, by around year 7 a new system
33355 equilibrium would be reached and the passing of major sediment loads would decline.
33356 Beginning in year 7, maintenance dredging of 0.25 MCY annually would be expected. Based on
33357 these sediment estimates, total dredging costs for the first 5 years is approximately \$108.7
33358 million. Over the 50-year period of analysis annualized dredging costs are \$6.1 million (annual
33359 equivalent dollars).

33360 Dredging estimates were also developed for the potential dredging costs that would be
33361 incurred by others in order to access the Federal navigation channel. These include local port
33362 facilities and/or private terminals that would require dredging to reestablish service under
33363 MO3. Total dredging volumes would range from an estimated 5 MCY in the first year, to 2.5

¹² Given the location of several port facilities near the Snake-Columbia confluence, it is assumed that the Federal navigation channel will be maintained to approximately lower Snake River RM 2.0.

33364 MCY for the next 4 years. The total dredging costs for the first 5 years post dam breach, are
33365 approximately \$143.1 million.

33366 Dredging operations are expected to remain similar to the No Action in other reaches of the
33367 Columbia navigation channel, with an estimated cost of \$67.1 million annually. In total, annual
33368 dredging costs would increase about 4.4 percent under MO3, from \$70.1 million annually to
33369 \$73.2 million.

33370 **Commercial Cruise Line Operations**

33371 As discussed in the No Action Alternative, approximately 18,000 visitors travel via cruise line
33372 along the lower Snake and Columbia Rivers each year. While it is uncertain how the cruise lines
33373 would respond to closure of the lower Snake River to navigation, it is clear that one of the
33374 primary draws of the trips are to see the Snake River. Given this, a substantial portion of these
33375 trips may be lost under MO3. For most of the typical 7-day cruise line trips, seven of the eight
33376 ports of call are in Region D, while one is located in Region C. Business revenues for cruise ship
33377 companies and ports where the vessels call between Astoria, Oregon, and Clarkston,
33378 Washington, would likely be adversely affected under MO3. Total estimated annual
33379 expenditures by approximately 18,000 cruise line passengers per year traveling on the lower
33380 Columbia and Snake Rivers is estimated to be \$15.6 million annually. Impacts associated with
33381 reduced expenditures on commercial ferry trips are discussed in the Regional Economic Effects
33382 section.

33383 **Commercial Ferry Operations**

33384 The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B
33385 would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out
33386 of the year under MO3 in average water years as well as in dry water years, similar to the No
33387 Action Alternative. In larger runoff years, the ferry would be inoperable for certain periods
33388 when Lake Roosevelt is lowered in April and May in order to reduce potential flooding effects
33389 downstream. In these higher water years, defined as conditions under the highest 20th
33390 percentile forecasted volume at The Dalles Dam, the Inchelium-Gifford Ferry would not be able
33391 to operate for approximately 29 consecutive days in the year under MO3 (or about 8 percent of
33392 the year in wet years), which is 2 days more than under the No Action Alternative (representing
33393 a 7.4% increase in the number inoperable days from the No Action Alternative). This would
33394 result from changes in operations at Grand Coulee Dam under this alternative.¹³ The average
33395 daily number of passengers on the ferry is approximately 410. (CTCR 2019). At this rate,
33396 approximately 820 ferry trips could be affected in wet years by under MO3. Longer inoperable
33397 periods would be expected in wetter years that require more FRM space.

¹³ Specifically, the impacts to ferry operation in wet years is likely due to the measures *Planned Draft Rate at Grand Coulee* and *Update System FRM Calculation* under MO3. The difference between MO3 and the other MOs is that *the Planned Draft Rate* includes a "flat spot" that has the same space requirement over a range of water supply conditions. The inclusion of the "flat spot" reduced the *Update System FRM Calculation* effect on the number of additional ferry outage

33398 **REGIONAL ECONOMIC EFFECTS**

33399 **Commercial Navigation and Transportation Systems**

33400 As discussed above, MO3 would necessitate changing the mode of transit for commodities that
33401 would have used the lower Snake River portion of the CSNS under the No Action Alternative.
33402 Changing the mode of transportation for these goods from commercial barge to road or rail
33403 would have regional economic implications. This section discusses potential regional economic
33404 effects associated with increased costs to the agriculture industry; increased demands for
33405 infrastructure, including highways, rail lines, grain elevators; impacts to port facilities and barge
33406 companies; impacts to support industries for the commercial cruise lines; and other city and
33407 local implications.

33408 **Costs to Agricultural Operations**

33409 The entities producing and shipping goods on the CSNS would also experience increased costs
33410 under MO3. While the increased expenditures to transport goods would benefit, to some
33411 degree, the road and rail industries and industries that support them, producers of
33412 commodities would need to absorb the cost increase in their operations. As described above,
33413 costs to farmers are likely to vary based on location.

33414 In order to illustrate how specific geographic locations would differ in terms of impacts of MO3,
33415 two hypothetical farmers were evaluated to illustrate how MO3 would affect their shipping
33416 choices and costs related to the scenarios provided above. The first example evaluates impacts
33417 to a farmer that is located near Colfax, Washington, and one farmer is located near Grangeville,
33418 Idaho.

33419 **Example 1: Farmer Near Colfax with Many Shipping Options**

33420 The first example evaluates impacts to a farmer that is located near Colfax, Washington. The
33421 Colfax farmer is located in an area where there is intense wheat production and where there
33422 are several different choices for shipping wheat to market. Under the No Action Alternative, the
33423 Colfax farmer would ship wheat using the least-cost option available, which would be to truck
33424 grain to the port at Almota on the lower Snake River at a cost of 23 cents per bushel. (Figure X)
33425 Once at the port of Almota, the barge rate to ship the wheat to Portland would be 46 cents per
33426 bushel, for a total shipping cost of 69 cents per bushel.

33427 Under MO3, where the option to utilize the lower Snake River for shipping would not be
33428 available, the Colfax farmer would choose the next cheapest option, which would be to ship
33429 wheat north to the McCoy shuttle rail facility at a cost of 21 cents per bushel (Figure Y). The
33430 Colfax farmer would then pay 51 cents per bushel to ship the wheat directly to Portland via rail
33431 for a total cost of 72 cents per bushel. As such, under Scenario 1, the No Rail Rate Increase
33432 Scenario, the farmer's costs would increase by 3 cents per bushel (4 percent).

33433 If the shuttle rail facility raises the rail rate by 25 percent from the No Action Alternative
33434 (Scenario 2), the Colfax farmer would continue to utilize the McCoy shuttle rate facility option,
33435 (Figure Y) but shipping costs would increase from 72 cents per bushel to 85 cents per bushel (21
33436 cents from the truck travel to the shuttle rail and then 64 cents per bushel rail rate), which
33437 would represent an increase of 23 percent.

33438 If shuttle rail facility raises the rail rate by 50 percent from the No Action Alternative, the Colfax
33439 farmer's next cheapest option would be to utilize the Lacrosse shuttle rail facility, which would
33440 increase shipping costs to \$1.07 per bushel (35 cents truck cost to Lacrosse and 72 cents per
33441 bushel shuttle rail), which would represent an increase of 55 percent (Figure Z).

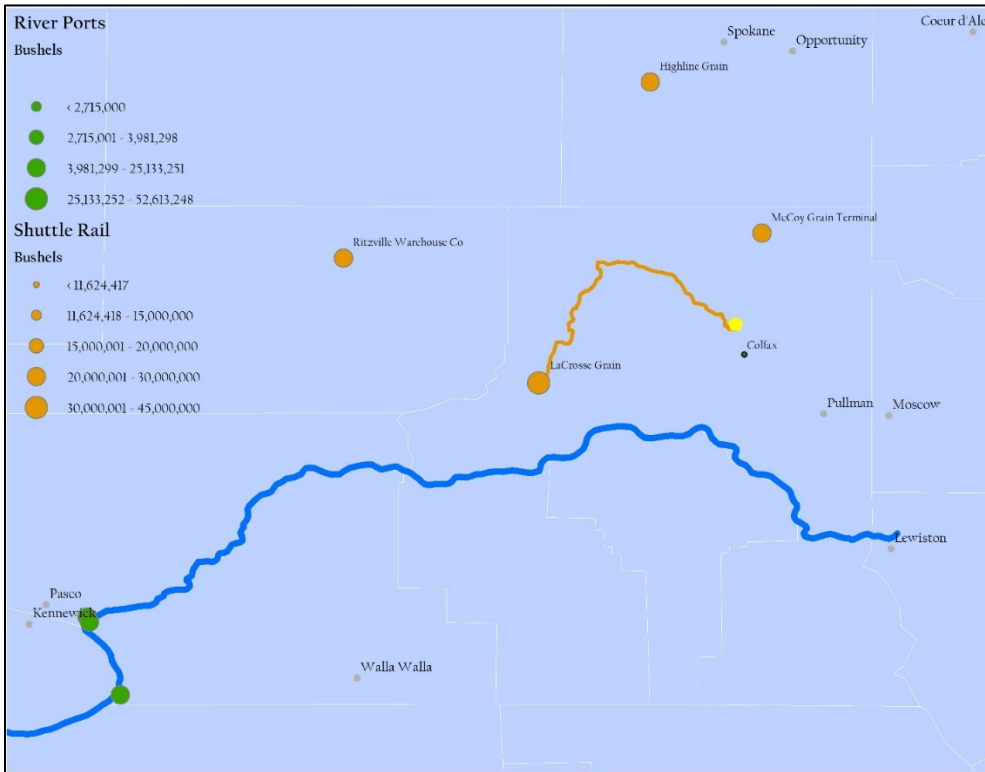


33442
33443 **Figure 3-215. Colfax-Area Farmer Transit Route Under the No Action Scenario**

33444 A second example evaluates impacts to a farmer that is located near Grangeville, Idaho. A
33445 farmer in Grangeville is located at the edge of wheat production in the Northwest and has
33446 relatively limited shipping options. Under the No Action Alternative, the Grangeville farmer's
33447 least-cost option would be to truck wheat from the farm to the Lewiston barge terminal at a
33448 cost of 47 cents per bushel and then pay another 47 cents per bushel barge rate to move the
33449 grain to Portland for a total cost of 94 cents per bushel (Figure XX). As such, shipping costs are
33450 approximately 36 percent higher than the Colfax farmer's shipping costs under the No Action
33451 Alternative.



33452
 33453 **Figure 3-216. Colfax-Area Farmer Transit Route Under Scenarios 1 and 2: No Rail Rate**
 33454 **Increase and 25% Rail Rate Increase**



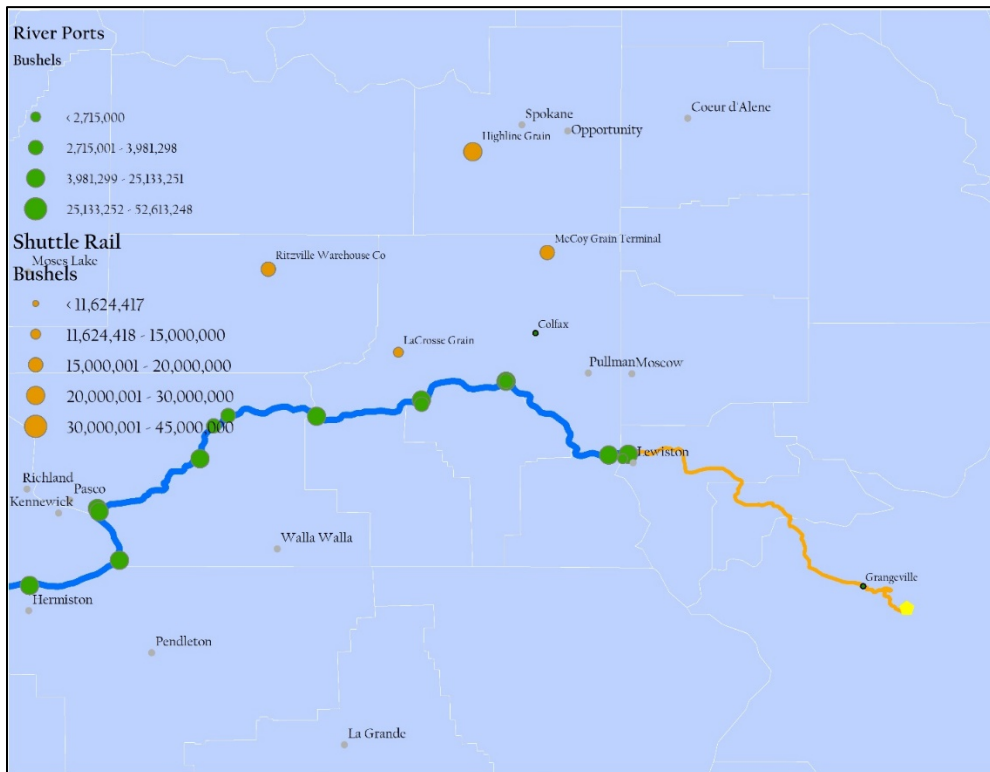
33455
 33456 **Figure 3-217. Colfax-Area Farmer Transit Route Under Scenario 3: 50% Rail Rate Increase**

33457 Example 2: Farmer near Grangeville with More Limited Shipping Options

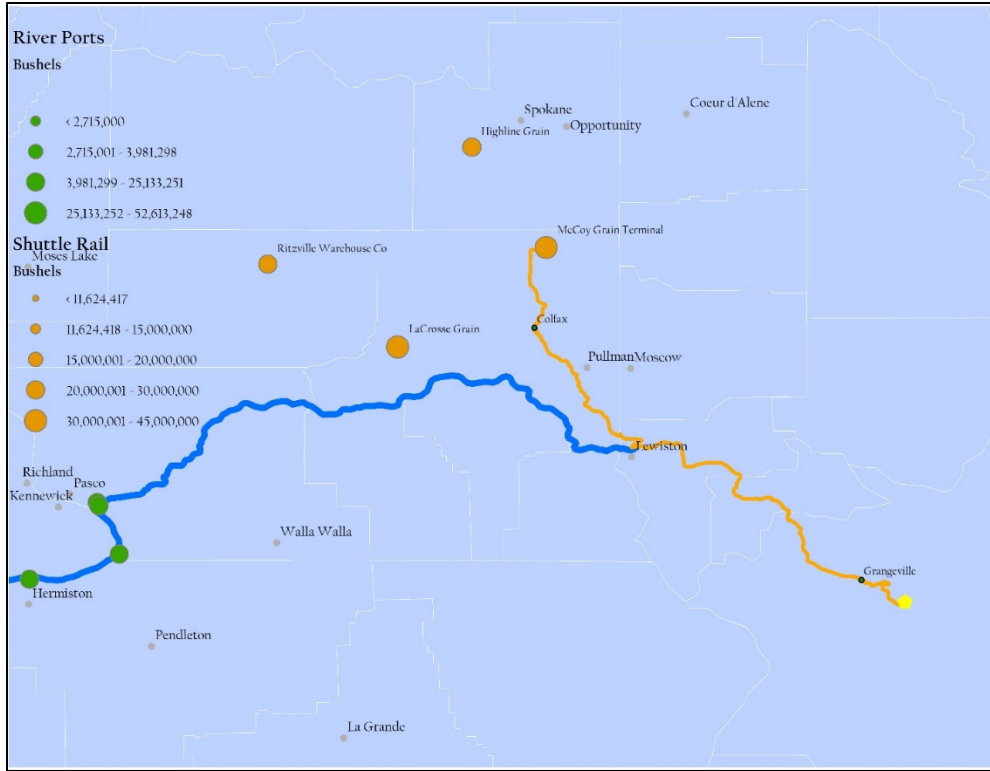
33458 Under MO3 when river barge is not available on the lower Snake River, the Grangeville farmer's
33459 next-best option would be to truck the wheat from the farm to the McCoy shuttle terminal at a
33460 cost of 75 cents per bushel and then to pay the 51 cents per bushel to ship the wheat via rail to
33461 Portland, for a total cost of \$1.26 per bushel. As such, under Scenario 1, the No Rail Rate
33462 Increase Scenario, costs would increase by 32 cents per bushel (34 percent).

33463 If the railroads begin raising rates by 25 percent or 50 percent (Scenarios 2 and 3), the
33464 Grangeville farmer would be better off trucking the grain all the way to the Tri-Cities for a cost
33465 of \$1.08 per bushel and then paying 36 cents per bushel to barge the grain to Portland at a total
33466 cost of \$1.44 per bushel. As such, under Scenarios 2 and 3, costs would increase by 50 cents per
33467 bushel (53 percent).

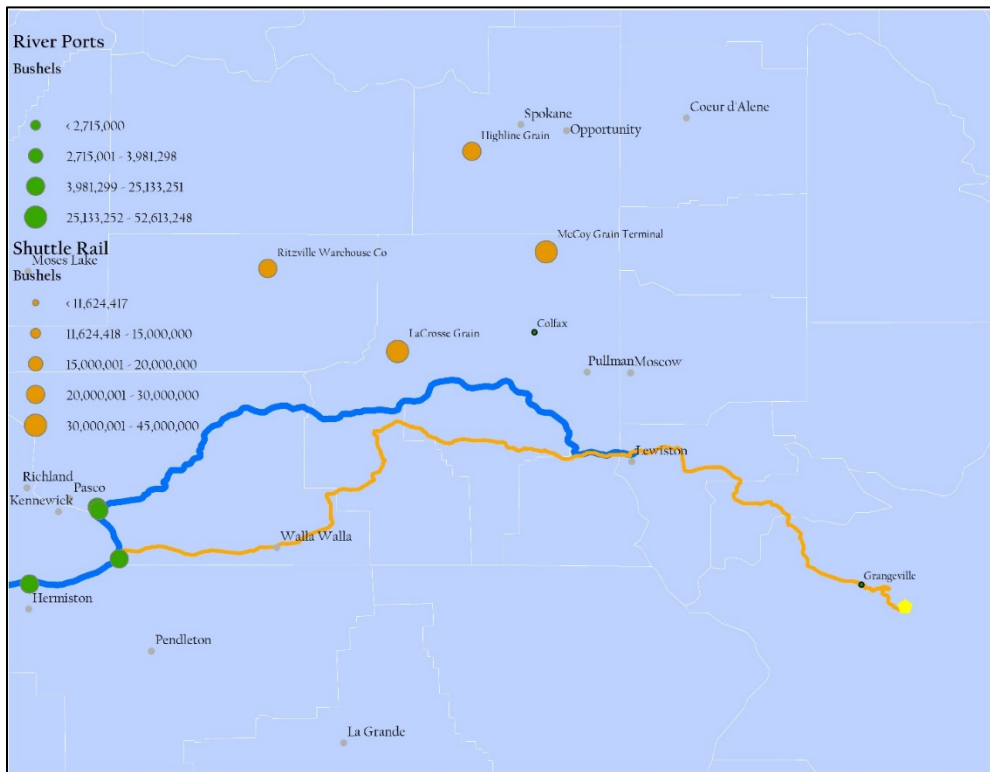
33468 The difference between the Grangeville farmer and the Colfax farmer is that the Grangeville
33469 farmer has higher transportation costs to begin with given that he is much farther from market
33470 and has limited transportation options in order gain access to those markets. Once those
33471 options are reduced, as would occur under MO3, the Grangeville farmer cost impacts would be
33472 much greater. Under MO3 when rail rates increase by 50 percent, the Grangeville farmer's
33473 costs would increase by 50 cents per bushel, compared with 39 cents per bushel for the Colfax
33474 farmer, both representing an increase in shipping costs of over 50 percent compared to the No
33475 Action Alternative.



33476
33477 **Figure 3-218. Grangeville-Area Farmer Transit Route Under the No Action Alternative**



33478
 33479 **Figure 3-219. Grangeville-Area Farmer Transit Route Under Scenario 1: No Rail Rate Increase**



33480
 33481 **Figure 3-220. Grangeville-Area Farmer Transit Route Under Scenarios 2 and 3: 25% and 50%**
 33482 **Rate Increase**

33483 Faced with increasing transportation costs of over 50 percent, profitability of farming in this
33484 region would be adversely affected. However, the analysis indicates the cost to transport wheat
33485 to market would still be less than costs paid by other wheat growers in the United States (e.g.,
33486 the Dakotas and Midwest). For example, with the current total cost of producing wheat being
33487 approximately \$6 per bushel, the estimated cost increase of \$0.07 (average increase under
33488 Scenario 1) to \$0.50 per bushel (for Grangeville farmer under Scenario 2 or 3) would represent
33489 a 1 to 8 percent increase in total production costs, marginally affecting competitiveness (Figure
33490 ZZ). The wheat grown in the Northwest is soft white wheat. This type of wheat is a preferred
33491 grain for Asian and Eastern countries; however, there is no guarantee wheat grown in the
33492 Northwest will be competitive now or in the future because there are so many factors that
33493 influence international commodity markets (e.g., trade agreements, the U.S. dollar, global
33494 supply, etc.). In general, wheat producers are 'price takers,' so keeping production costs lower
33495 are critical for remaining competitive. Favorable conditions for Northwest wheat growers that
33496 help them stay competitive are: (1) the natural environment of the Palouse region (weather,
33497 soils) is ideal for growing this type of wheat, which leads to some of the highest yields per acre
33498 in the world, and (2) proximity of Northwest export ports. Currently, the cost to transport
33499 wheat to market is quite low relative to other parts of the United States and world.

33500 **Infrastructure Costs**

33501 With dam breaching and a shift of commodities from shipment on the lower Snake River to
33502 other shipping modes, demands for the region's land-based transportation and grain handling
33503 infrastructure would increase. These increases in infrastructure demands could vary widely
33504 depending on factors such as the changes in rail rates, which influence the mix of alternative
33505 transportation modes that are utilized. In our scenarios, the largest demands on rail would
33506 occur under Scenario 1, when rail rates are assumed not to increase and rail transit would be
33507 relatively more attractive. In contrast, increased highway use would be highest under Scenario
33508 3, when rail rates are assumed to increase by 50 percent.

33509 This section addresses impacts to the rail system, potential effects to rail car demands, highway
33510 system requirements, and grain elevator capacity requirements that may occur under the
33511 various scenarios, as well as potential costs associated with these demands. Estimates were
33512 developed for these costs based on input from local stakeholders, as well as published reports
33513 including the 2002 Lower Snake River Feasibility Study/EIS (2002 EIS), and the 1999 Lund
33514 Report. Both of these studies considered infrastructure investments that would be needed if
33515 the lower Snake River dams were breached.

33516 It should be noted that the high rail demand scenario and the high highway demand scenario
33517 would not both occur. In addition, infrastructure investments are transitional costs, and would
33518 primarily be borne by private entities, including rail lines and grain shippers. Over time, prices
33519 should adjust to cover these costs. Some highway costs would be transferred to the trucking
33520 industry through fees, though most costs would likely be borne by public entities. Because of
33521 the high level of uncertainty surrounding these costs, interpretation should be done with
33522 caution.

33523 Highways and Highway Congestion

33524 Transportation officials and regional policy planners are often concerned with how closure (or
33525 opening) of one mode option impacts truck traffic and ultimately impacts the highway system.
33526 The comparisons between how each of the TOM scenario results in impacts on the public
33527 highway system is best captured in comparing the ton-miles between different origin-
33528 destination types in each scenario. The ton-mile more accurately captures the comparison in
33529 volume and distance across different freight modes. But often planners are also concerned with
33530 absolute number of truck trips. These comparisons may also be made utilizing the same tables
33531 and dividing the total volume (bushels) for each truck origin-destination type by 1,000 (the
33532 approximate capacity of the typical grain truck). Depending on the scenario, truck ton-miles
33533 may experience an increase of 19 percent under Scenario 1, when rail rates are not assumed to
33534 increase, to 84 percent when rail rates increase by 50 percent under MO3, when compared to
33535 the No Action Alternative. Since the TOM captures all grain movements leaving the farm, the
33536 total number of trucks for shipments leaving the farm doesn't change between each scenario
33537 given that total grain production would not be anticipated to change. But the distribution of
33538 shipments and truck trips to the various destinations after leaving the farm does change once
33539 the choice set changes. The most immediate and noticeable impact comparing the No Action
33540 Alternative to MO3 is that the number of truck trips going to the river ports decreases by
33541 80,086 trucks as farmers now choose the next least-cost option, which would be shuttle rail
33542 under Scenario 1. That would result in an additional 46,638 trucks going from the farm to
33543 elevators with rail access instead and an additional 32,495 trucks to elevators with rail access
33544 and an additional 892 trucks going from the farm to elevators without rail access. Also, under
33545 Scenario 1, an additional 498 truck trips would occur for trans-shipments between elevators
33546 without rail to those with rail that didn't occur under the No Action Alternative. The net
33547 additional trips under Scenario 1 is 13,515 truck trips compared to the No Action Alternative.

33548 Once railroads increase rail rates by 25 percent under Scenario 2, truck trips to the remaining
33549 Columbia River ports would become more attractive (compared to shuttle rail with higher
33550 rates) and shippers would begin to increase truck trips to those ports as elevator (both with and
33551 without rail access) to river port truck shipments increase. The total net additional trips under
33552 this scenario would be 32,249 truck trips compared to the No Action Alternative, with an
33553 additional 25,711 truck trips due to elevator to river port shipments. Truck shipments to shuttle
33554 elevators would decline under Scenario 2 compared Scenario 1, but would still be higher than
33555 under the No Action Alternative.

33556 Once railroads increase rail rates by 50 percent, the net additional trips would increase to
33557 79,250 truck trips compared the No Action Alternative, with the majority of that coming from
33558 elevator to river port movements.

33559 Changes that would result in increased truck usage would also add to vehicular traffic and
33560 congestion. As shown in Figure 3-208 (Scenario 2 map), Highway 12 and Highway 395 appear
33561 likely to experience increases in traffic. These, in turn, would have impacts on infrastructure
33562 costs. In particular, the costs to maintain roadways may increase under MO3. Using estimates

33563 of road resurfacing costs in eastern Washington per ton-mile from published literature of \$0.01
33564 (state roads) to \$0.04 per ton-mile (county roads). Based on likely route patterns, it was
33565 assumed that 60 percent of increased traffic would occur on state roads and 40 percent would
33566 occur on county roads. Under Scenario 1, costs to maintain the roads due to the increased truck
33567 traffic would be approximately \$2 million annually. Under Scenario 2, where truck use would
33568 increase moderately, increased pavement damage costs would be approximately \$4 million
33569 annually. Under Scenario 3, where truck use would increase most substantially, increased
33570 pavement damage costs would be approximately \$10 million annually.

33571 Rail Lines and Demand for Rail Cars

33572 Depending on the price increases by rail lines under MO3, rail traffic would be anticipated to
33573 increase when compared to the No Action Alternative when barges would share the
33574 transportation load. The higher the increase in rail prices, the lower the increased demand for
33575 rail (this is because other options, such as transit via truck to the Tri-Cities area, would be
33576 relatively more affordable as rail prices increase). Rail ton-miles may increase by as much as 86
33577 percent under Scenario 1, when rail rates are not assumed to increase, or by 63 percent under
33578 Scenario 2 (25 percent rail rate increase). Under Scenario 3, with a 50 percent rail rate increase,
33579 rail ton-miles would be anticipated to decrease by 2 percent (under Scenario 3). As such,
33580 although Scenario 1 may be the most unlikely, it also defines the highest increase in demand for
33581 rail.

33582 *Increased capacity at shuttle rail facilities.* As discussed in the social welfare section, the
33583 increase in rail demand under Scenario 1 (no rail rate increase) and Scenario 2 (25 percent rail
33584 rate increase) would represent an increase in the demand for shuttle rail capacity that would
33585 exceed current shuttle rail capacity. Increased capacity needs would range from approximately
33586 38 million bushels under Scenario 1 (approximately the size of one shuttle rail facility) to 19
33587 million bushels under Scenario 1 (less than one shuttle rail facility). Increased shuttle rail
33588 capacity would not be required under Scenario 3. Costs to develop this increased capacity
33589 would vary depending on the type of storage provided. Increased investments at ports around
33590 the Port of Pasco would also likely be required. Based on input from local shuttle rail facility
33591 operators, the cost to construct a new shuttle rail facility with the ability to move 25 million
33592 bushels of wheat/barley per year is approximately 25 million per year. Based on this it is
33593 estimated that one to two shuttle rail facilities could be needed at a cost of \$25 to \$50
33594 million.¹⁴

33595 *Demand for trains and rail cars.* As discussed in the social welfare effects section, the number of
33596 unit trains (with approximately 110 cars per train) would be anticipated to increase under
33597 Scenario 1 (no rail rate increase) from approximately four trains to approximately eight trains
33598 per month at each shuttle rail facility. Overall, the number of shuttle rail unit train trips in the

¹⁴ The 1998 Lund Report estimated that costs to increase rail elevator capacity along eastern Washington's rail network would range from \$88 and \$105 million, or \$6.3 million and \$7.5 million annualized over 50 years (inflated to 2019 dollars). Since 1998, four shuttle rail facilities have been opened in eastern Washington, reducing the additional rail elevator capacity that would be needed.

33599 region would increase by 185 annually, and the number of shuttle rail cars loaded would
33600 increase by over 20,000 under Scenario 1. This would represent an increase of 94 percent over
33601 current shuttle rail activity. Scenario 2 also anticipates increased demands are somewhat lower,
33602 at 133 trains and 14,600 rail cars. Similarly, the 2002 EIS found the unavailability of variable
33603 inputs, such as locomotives, rail cars, and train crews could lead to serious short-turn capacity
33604 constraints for mainline rail lines. However, in the long run, these services would be acquired
33605 “at prices that would not affect rail rates if rail carriers face effective competition in rail-served
33606 markets” (2002 EIS, Appendix I).

33607 *Costs to improve condition of shortline rail.* Local stakeholders as well as WSDOT stated that the
33608 shortline rail lines are in need of improvement, and would require significant investment to
33609 handle higher volumes. Similarly, the 2002 EIS found that shortline rail lines were in generally
33610 poor condition at the time. These rail lines were characterized as “spin-offs of low volume, low
33611 revenue/profit segments of the mainline system and maintenance tends to be deferred.
33612 Needed improvements included interchanges with mainline railroads, track upgrading, and
33613 other. Costs of shortline rail improvements were estimated to range from \$30 million to \$36
33614 million or \$2.1 million to \$2.5 million annualized over 50 years (inflated to 2019 dollars). These
33615 would be generally private investments, although public investments of the PCC could also be
33616 required.

33617 *Congestion on mainline rail lines.* Concerns have been raised about congestion on the mainline
33618 rail lines; however, based on available information congestion and associated capacity
33619 constraints are likely more associated with shuttle rail facilities and/or shortline rail upgrades.
33620 Similarly, the 2002 EIS found that diversion of lower Snake River traffic to rail lines would
33621 increase rail traffic, but would not create substantial capacity issues along the mainline rail
33622 corridor. Even though some congestion was expected, the 2002 EIS found that BNSF and UP
33623 would be able to address capacity issues without increasing long-term marginal costs or
33624 changing rates. When the EIS 2002 interviewed a representative at BNSF, BNSF asserted that
33625 existing rail capacity would sufficient to handle the increase in traffic with dam breaching (2002
33626 EIS, Appendix I).

33627 ***Effects to Ports and Barge/Towboat Companies***

33628 The analysis finds that under Scenario 1, barge volume would decrease by 64 percent on the
33629 system relative to the No Action Alternative (some volume would continue to transit the
33630 Columbia River below the breached dams). Under Scenario 2, barge traffic would also decrease
33631 by 52 percent. Reductions would be less under Scenario 3, when rail rates are the highest,
33632 when barge volumes would be reduced by 22 percent. A change in transportation mode away
33633 from barge would affect regional businesses that support port and barge activities as well as
33634 associated employment opportunities, particularly in the short term, as businesses adjust to the
33635 new shipping conditions and employment demands. Under this scenario, adverse effects to
33636 companies reliant on barge transit, such as towing companies, could be adversely affected. As
33637 discussed in Section 3.10.2, *Affected Environment*, a small number of companies specialize in
33638 operating barges and tow boats on the CSNS. These operators employ approximately 450

33639 employees, which range from captains and crews to tugboat operators, shipping handlers, to
33640 boat builders. Many crew members permanently reside in the greater Portland area, but some
33641 reside in upriver areas (Tidewater Barge Lines 2020; Shaver Transportation Company 2020). The
33642 commercial navigation industry supports employment for a wide range of transportation and
33643 material moving occupations. Some of these positions, such as material moving workers,
33644 including freight, stock, and material movers, may be readily transferable to support for road or
33645 rail transportation activities, while others, such as boat captains, pilots and operators, and ship
33646 engineers, would not be transferable, and could result in relocation of some workers to areas
33647 downstream or to other professions not dependent on river navigation. These companies
33648 report that many of their employees are long term, having niche experience and skills that
33649 would likely be difficult to transfer to other industries. (Tidewater Barge Lines 2020; Shaver
33650 Transportation Company 2020). They also report that approximately 50 percent of their
33651 business is conducted on the lower Snake River, and surmise that removal of the ability to
33652 utilize the river could threaten their ability to maintain profitability.

33653 Increased demand for rail operators as well as for truck transport and support services would
33654 increase under this alternative. Industry representatives have noted that an increased demand
33655 for trucking services would likely result in a shortage in the availability of trucks drivers in the
33656 short term (Port of Lewiston and industry stakeholders 2019).

33657 **Commercial Cruise Line Operations**

33658 Total estimated annual expenditures by approximately 18,000 cruise line passengers per year
33659 traveling on the lower Columbia and Snake Rivers is estimated to be \$15.6 million annually
33660 under the No Action Alternative. As discussed in the No Action Alternative section, this assumes
33661 that passengers would typically spend 7 days on the Columbia and Snake Rivers, and would
33662 spend approximately \$124 per day in the region (Port of Lewiston/Shoreline Excursions 2019).
33663 These expenditures would create demand for approximately 230 jobs in the region, and would
33664 generate \$6.2 million in labor income, and \$17.8 million in output (sales). Most of these effects
33665 would be in Region C, with remaining expenditures in Region D. This is because most of time on
33666 cruises is spent in upriver areas. While it is uncertain how the cruise lines would respond to
33667 closure of the lower Snake River to navigation under MO3, it is clear that one of the primary
33668 draws of the trips are to visit the lower Snake River areas in Regions C and D. Given this, a
33669 substantial portion of these trips and the expenditures associated with them may be lost under
33670 MO3. To the extent that visitors no longer visit the lower Snake River, these expenditures
33671 would be lost to that area. The areas around ports of call, and particularly Lewiston, Idaho, and
33672 Clarkston, Washington, which are the final destination points for typical cruise line visitors and
33673 where more time is typically spent by passengers, could experience the most changes in
33674 regional tourist expenditures associated with these changes. However, economic losses would
33675 be experienced along the route at ports of call from Astoria, Oregon to Lewiston, Idaho.

33676 **Commercial Ferry Operations**

33677 The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B
33678 would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out

33679 of the year under MO3 in average water years as well as in dry water years. The Inchelium-
33680 Gifford Ferry would not be able to operate for approximately 29 consecutive days in the year
33681 under MO3 (or 8 percent of the year) in wet years, which is 2 days more than under the No
33682 Action Alternative (representing a 7.4 percent increase in the number inoperable days from the
33683 No Action Alternative). Longer inoperable periods would be expected in wetter years that
33684 require more FRM space. In those years and for those days, expenditures associated with these
33685 trips via ferry would likely be delayed or would not take place in the same locations.

33686 **City/Local Effects Associated with Changes in Commercial Navigation, Cruise Lines, and Ferry**
33687 **Operations**

33688 Cities and towns provide labor and services to the commercial navigation industry. When
33689 shipping modes shift away from barge, cities and towns that provide services to the industry
33690 will be affected.

33691 One method to capture the overall regional economic effects associated with shipping cost
33692 increases to the agriculture industry is to assume that increased transportation costs would
33693 result in decreased profitability of grain production, which would manifest itself in reduced
33694 local expenditures and investments, including some reduced labor demand. By assuming the
33695 lost profitability would be reflected in lost farm revenues, this analysis can provide an
33696 approximate estimate of regional effects of transportation cost increases.

33697 Using this method, increased shipping costs (assumed to represent reductions in farm income)
33698 of \$159 to \$192 million would be estimated to result in a reduction in demand for employment
33699 of 116 to 402 jobs, and may result in reductions of regional economic output of \$22 million to
33700 \$77 million (CRSO EIS IMPLAN analysis 2020). This estimate does not include potential impacts
33701 associated with reduced demand for barge employment or an increased demand for trucking
33702 employment that would accompany these shifts.

33703 Because trucking is more labor intensive than barge operations, increased trucking demand
33704 would likely increase employment demand for shipping handlers. However, stakeholders have
33705 noted that, in the short term, an already tight market for truck drivers would be made even
33706 tighter.

33707 Further, the estimate of employment effects does not consider additional changes in
33708 employment demand that may occur associated with industries that depend on river navigation
33709 other than agriculture. These include industries that rely on the river for inputs or for
33710 discharges, such as the large papermill in Lewiston, Idaho, that utilizes barges to provide wood
33711 chips to the facility (City Manager of Lewiston, Idaho 2019; Clearwater Paper 2020). City
33712 managers in towns along the river are also concerned about less direct effects of dam breach,
33713 including reduced appeal of the area for aluminum boat building, which has located in the
33714 Lewiston and Clarkston areas (City Manager of Lewiston, Idaho 2019; Mayors of Asotin,
33715 Washington and Clarkston, Washington 2019).

33716 In addition to a loss of navigation on the rivers, upriver communities on the lower Snake River
33717 are concerned about the loss of tourists that currently visit the areas via cruise ships, as
33718 discussed above.

33719 **OTHER SOCIAL EFFECTS**

33720 **Commercial Navigation and Transportation Systems**

33721 As noted, the navigation channel on the lower Snake River would become inoperable under
33722 MO3, resulting in substantial changes to port operations. This would affect approximately 14
33723 river terminals on the lower Snake River. Some terminals would likely transition from being
33724 water-based to other modes; other terminals could close. These structural changes to the
33725 economic base would affect regional demand for some labor categories and could affect
33726 commuting patterns as well as housing demand. The loss or transition of port operations in
33727 some communities could also result in community-level effects associated with changes in the
33728 character of the communities and community identity from communities that have evolved to
33729 depend on reservoir conditions to communities more reliant on river and perhaps land-based
33730 recreation and other services.

33731 As discussed above, depending on the scenario, truck ton-miles may experience an increase of
33732 19 percent (under Scenario 1, when rail rates are not assumed to increase) to 84 percent (when
33733 rail rates increase by 50 percent) under MO3 when compared to the No Action Alternative. Rail
33734 ton-miles may increase by as much as 86 percent (under Scenario 1, when rail rates are not
33735 assumed to increase) or decrease by 2 percent (under Scenario 2, when rail rates increase by 50
33736 percent). As discussed in Section 3.8, *Air Quality and Greenhouse Gases*, these modal
33737 transportation changes would likely lead to an increase in air pollutant emissions, specifically
33738 HAPs, VOCs, CO, PM, and NO_x, from rail and truck transportation, under MO3 relative to the No
33739 Action Alternative. These air pollutants have a variety of adverse health and environmental
33740 effects including respiratory health effects. In addition, many of these air pollutants react in the
33741 atmosphere to form ozone as well as haze, which can negatively affect regional visibility,
33742 particularly in national parks and scenic areas such as the Columbia River Gorge Scenic Area.
33743 Regional haze is a key concern in these areas as it creates visibility issues that affect
33744 recreational and scenic value. Air quality studies of the Gorge Scenic Area identified on-road
33745 vehicles as a source of the regional haze (ODEQ 2011). See Section 3.8 and Chapter G-4 of
33746 Appendix G for additional details on regional haze and the air quality analysis.

33747 Greenhouse gas emissions would also increase under MO3 compared to the No Action
33748 Alternative since rail and truck transportation generate more carbon dioxide (CO₂) per ton-mile
33749 of freight compared to barge transportation. Specifically, truck transportation can emit nearly
33750 10 times more CO₂ per ton-mile than inland barges. As a result, decreases in barge
33751 transportation and increases in truck and rail transportation under MO3 would result in an
33752 increase in CO₂ emissions of up to 30 percent. Table 3-247 summarizes the carbon dioxide
33753 emissions by mode and the difference from No Action Alternative. Section 3.8 discusses the air
33754 quality and greenhouse gases analysis further.

33755 **Table 3-247. Navigation CO₂ Emissions by Type under Multiple Objective Alternative 3 and No**
33756 **Action Alternative in 2022 (MMT CO₂)**

Emissions (MMT CO ₂) by Freight Transportation Mode	No Action	MO3, No Rail Rate Increase	MO3 with Rail Rate Increase
Truck	0.032	0.039	0.060
Rail	0.017	0.032	0.017
Barge	0.017	0.0061	0.013
Total	0.067	0.077	0.090
Difference from NAA (MMT CO ₂)	–	0.010	0.023
Difference from NAA (%)	–	15	30

33757 Changes in transportation modes would also have implications for public safety. As noted in
33758 Section 3.10.3.1, *Methodology*, accident rates are generally higher for road travel than travel by
33759 either barge or rail (Inland Rivers Ports & Terminals, Inc. 2019). As such, accident rates would
33760 be expected to increase under MO3.

33761 **Commercial Cruise Line Operations**

33762 As discussed above, it is uncertain how the cruise lines would respond to closure of the Snake
33763 River to navigation under MO3. However, it is clear that one of the primary draws of the cruise
33764 line trips are visits to the Snake River areas in Region C. Given this, a substantial portion of
33765 these trips and the expenditures associated with them may be lost under MO3 when that area
33766 would be rendered inaccessible to navigation. To the extent visitors would no longer visit the
33767 Snake River, these expenditures would be lost to the Snake River port areas where the cruise
33768 lines would have docked. The areas around ports of call, and particularly Portland, Oregon,
33769 which is the typical departure point for cruise line visitors, as well as Lewiston, Idaho, and
33770 Clarkston, Washington, which are the most common final destination points for cruise line
33771 visitors, could experience the most reduction in regional tourist expenditures associated with
33772 these changes. Tourism businesses could be adversely affected by these changes in
33773 expenditures, which could be more apparent in rural areas, such as near the Port of Benton,
33774 where local economies are more dependent on these expenditures, than larger urban areas.

33775 **Commercial Ferry Operations**

33776 The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B
33777 would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out
33778 of the year under MO3 in average water years as well as in dry water years. MO3 would result
33779 in a loss of 2 additional days of operations by the Inchelium-Gifford Ferry in wet years for a total
33780 of 29 consecutive days without ferry operations. Longer inoperable periods would be expected
33781 under more extreme high-water years. In those years and for those days, travel from remote
33782 communities that use the ferry would not be possible. Changes in access for the remote
33783 communities during those days would reduce access to healthcare and educational facilities, in
33784 addition to food and shopping resources. Without the ferry, commuters and others who need

33785 to make the trip must take a 70-mile detour, which adds substantial mileage, gas costs, time, air
33786 emissions, and other effects (Spokesman-Review 2017). Since the ferry is free and reduces
33787 driving time and distance, the loss of ferry service will create additional transportation costs.

33788 **SUMMARY OF EFFECTS - MULTIPLE OBJECTIVE ALTERNATIVE 3**

33789 Major adverse effects would be anticipated under MO3 as commercial navigation on the lower
33790 Snake Shallow section would effectively be eliminated. In addition, the area at the confluence
33791 of the lower Snake River with the Columbia River and within the McNary Reservoir would have
33792 increased sedimentation for approximately 2 to 7 years following dam breach, when
33793 sedimentation rates are anticipated to stabilize. Grain shippers, who are the primary shippers in
33794 the lower Snake River, would face increased regionwide transportation costs over the short and
33795 long term that would range from \$0.07 to \$0.24 per bushel. Cost increases for specific shippers
33796 would depend upon location and would vary throughout the region, depending on
33797 transportation options at each location. Generally, those grain shippers that are the farthest
33798 from alternative shipping locations (shuttle rail facilities or river ports on the Columbia River)
33799 would be the most negatively impacted. Scenario 1 under MO3 anticipates a 10 percent
33800 increase in shipping costs for grain shippers. This scenario is heavily dependent on two
33801 assumptions: (1) the existing shuttle rail facilities are able to accommodate most of the grain
33802 that otherwise would have used the lower Snake River ports (slightly more than double existing
33803 shuttle rail facility volumes) and (2) the shortline railroads are able to accommodate increased
33804 volumes going to shuttle rail facilities. Under this scenario, increased rail demands would likely
33805 exceed current shortline rail capacity by 38 million bushels. This would likely require increased
33806 investments in shortline rail capacity to meet demand, with costs that could range from a total
33807 of \$25 to \$50 million, assuming new facilities would be required to accommodate the increase
33808 in capacity. In addition, upgrades to existing shortline rail lines of approximately \$30 to \$36
33809 million, or approximately \$2 million annually may be needed.

33810 Under Scenario 2, there would be a 22 percent increase in total transportation costs
33811 regionwide. As under Scenario 1, increased rail demands would likely exceed current shortline
33812 rail capacity, but somewhat less than under Scenario 1 (19 million bushels). Costs to increase
33813 capacity could be as high as \$25 million under this scenario. Truck use would moderately under
33814 Scenario 2, which would increase wear and tear on roadways and could result in additional road
33815 repair costs of up to \$4 million annually.

33816 Under MO3 Scenario 3, there would be a 33 percent increase in total transportation cost
33817 regionwide. However, some individual shippers may experience increases that are more than
33818 double this amount, depending on location. Under this scenario, truck use would substantially
33819 increase, which would result in increases in vehicular accident rates, highway traffic and
33820 congestion. In addition, additional wear and tear on roadways could result in additional road
33821 repair costs of up to \$10 million annually. Columbia River navigation would continue to be
33822 important in the region below Pasco under MO3. Effects of these mode changes would be most
33823 acute in the short term. As the industry adapts over time, more rail capacity and associated
33824 storage would likely be added in the region to accommodate freight affected by loss of river

33825 navigation on the lower Snake River. In any of these scenarios, regional economic effects would
33826 occur as the jobs and income provided by the four primary commercial navigation ports would
33827 be curtailed, including the Port of Lewiston, the Port of Clarkston, the Port of Whitman County
33828 (Wilma, Almota, Central Ferry), and the Port of Garfield.

33829 Cruise ship transit to the lower Snake River would not be possible. Given this, a substantial
33830 portion of cruise lines trips may be lost under MO3. This could represent a loss of up to 18,000
33831 visitors and \$15 million in direct expenditures per year.

33832 MO3 would result in negligible to the operations of the Inchelium-Gifford Ferry, which would be
33833 precluded for 2 additional days under MO3 relative to the No Action Alternative in wet years
33834 (for a total inoperable period of 29 consecutive days) and could represent 820 fewer ferry trips.
33835 During those years negligible social welfare effects could be experienced due to the slightly
33836 longer inoperable period. Negligible effects due to loss or redistribution of expenditures
33837 associated with the ferry trips could also occur. Changes in access to healthcare and
33838 educational facilities, in addition to food and shopping resources could result in minor adverse
33839 effects. Other ferries would not be affected under M03.

33840 Some tribes have commented that there are ongoing adverse social and cultural effects as well
33841 as socioeconomic costs to Indian tribes and tribal communities from present and cumulative
33842 effects of the current navigation system, under all MOs. They note that these cumulative
33843 effects, along with impairment of Indian treaty-reserved rights, may be reduced under MO3
33844 (Nez Perce Tribe 2020).

33845 Table 3-248 provides a summary of the navigation and transportation system effects of MO3.

33846 **Table 3-248. Changes in Economic Effects of Navigation and Transportation Under Multiple Objective Alternative 3 Relative to No**
33847 **Action Alternative, over 50 years**

Region	Social Welfare Effects	Regional Economic Effects	OSE
Region B	Negligible effects due to decrease in Inchelium-Gifford Ferry operations for 2 additional days of operations in wet years (for a total of 29 consecutive days), which could represent 820 ferry trips. ^{1/} Longer inoperable periods would be expected in wetter years that require more FRM space.	Negligible effects due to loss or redistribution of expenditures associated with approximately 820 Inchelium-Gifford Ferry trips in wet years. Longer inoperable periods would be expected in wetter years that require more FRM space.	Minor adverse effects due to reduced access to healthcare and other services reached by the Inchelium-Gifford Ferry for 2 additional days of operations in wet years (for a total of 29 consecutive days). Longer inoperable periods would be expected in wetter years that require more FRM space.
Region C (Snake Shallow)	Major adverse effects as commercial navigation on the Snake Shallow section would effectively be eliminated. Shipping and cruise ships would no longer be able to operate. All ports on the lower Snake River would be inaccessible without additional dredging. Shipping costs would increase on average between 10 and 33 percent, but costs for individual shippers would vary based on location.	Major adverse effects as the jobs and income provided by the four primary commercial navigation ports would be curtailed: Port of Lewiston, the Port of Clarkston, the Port of Whitman County (Wilma, Almota, Central Ferry), and the Port of Garfield. Investments in infrastructure may be required, including upgrades to rail infrastructure, added shuttle rail capacity, and increased road maintenance costs. Adverse effects due to reductions in regional economic benefits to port cities where cruise line expenditures would have occurred; redistribution of regional demands for material handlers. Additional dredging would be required in the McNary pool to access port facilities for 2 to 7 years. Reductions in regional economic benefits to port cities where cruise line expenditures would have occurred; redistribution of regional demands for material handlers.	Major adverse effects as sense of community and identity associated with ports could be negatively affected. Adverse effects to accident rates; increased highway traffic and congestion. Tribes have commented that there are ongoing social and cultural effects as well as socioeconomic costs to Indian tribes and tribal communities from present and cumulative effects of the current navigation system. They note that these adverse effects, along with impairment of Indian treaty-reserved rights, may be reduced under MO3.
Region D (Columbia Shallow)	Increased dredging costs would be required to maintain at ports above McNary Dam. Those river ports still operating on the Columbia River would experience a large volume increase, mostly from arriving shipments via rail. Cruise lines would be curtailed and may	Ten primary ports would continue to operate. Ports of Benton, Kennewick, Pasco, Walla Walla, Umatilla, Morrow, Arlington, the Dalles, Klickitat, and Camas-Washougal may experience increases in traffic and volume following dam breach. Major effects due to reductions in regional economic benefits to port cities where cruise line expenditures would have occurred.	Major adverse effects as sense of community and identity associated with ports may be negatively affected in some locations, particularly above McNary Dam if dredging access is not maintained.

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Region	Social Welfare Effects	Regional Economic Effects	OSE
	stop operating due to lack of access to the lower Snake River.		
Region D (Deep Draft)	No effects to the deep-draft segment of the CSNS, which would continue to operate consistent with current levels in terms of shipping. Cruise line operations would be curtailed and may stop operating. Considerable dredging operations would continue, consistent with current operations.	Primary ports would continue to operate and support jobs and income: Ports of Vancouver, St. Helens, Kalama, Longview, Astoria, Ilwaco. Major effects due to reductions in regional economic benefits to port cities where cruise line expenditures would have occurred (especially Portland).	Minor effects to sense of community and identity associated with ports would continue.

33848 1/ "Wet" water years are defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam.

33849 **3.10.3.6 Multiple Objective Alternative 4**

33850 While a complete list of the measures employed for MO4 may be found in Chapter 2, this
33851 section focuses on measures that may affect navigation. A number of planned structural
33852 measures under MO4, such the addition of spillway notch weirs or modifying turbine intake
33853 bypass screens that cause juvenile lamprey impingement, are unlikely to have measurable
33854 impacts to navigation in the CSNS. The *Drawdown to MOP, Winter System FRM Space, Spring &*
33855 *Fall Transport* measures may change the costs for vessel movements on the CSNS by altering
33856 the quantity or the timing of the flows. The *Spill to 125% TDG* measure operations may increase
33857 shoaling in the navigation channel, affecting sediment accumulate. In addition to these
33858 measures, commercial ferry operations on Lake Roosevelt have the potential to be affected by
33859 operational measures at Grand Coulee that result in lower reservoir levels in the early spring
33860 (*Winter System FRM Space, 0.8 foot SRD, etc.*)

33861 A few operational measures within MO4 such as conducting or ceasing juvenile fish transport
33862 will not physically affect flow levels, so they are not considered for this analysis. Operational
33863 measures that affect changes at Hungry Horse Reservoir, Chief Joseph Dam, Lake Roosevelt, or
33864 Grand Coulee Dam are assumed to not impact navigation due to the distance between these
33865 projects and the lower Columbia navigable channel.

33866 **SOCIAL WELFARE EFFECTS**

33867 **Commercial Navigation and Transportation Systems**

33868 Table 3-249. shows the difference between MO4 and the No Action Alternative in terms of flow
33869 days. The H&H data used as input into the SCENT model shows that MO4 would have slightly
33870 fewer days in normal and high flow conditions and a greater number of days in the low
33871 category than the No Action Alternative. In both the shallow-draft and deep-draft segments of
33872 the river, there would be approximately 9 more days of average annual low flows under MO4
33873 than under the No Action Alternative.

33874 **Table 3-249. Changes in Average Commercial Navigation Flow Days Under Multiple Objective**
33875 **Alternative 4 Relative to No Action Alternative, over 50 years**

River Segment	Number of Days Under Various Flow Condition (Days Per Year)					Number of Days Experiencing Draft Restriction (Days Per Year)					
	Low	Normal	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft
Shallow	8.5	(7.4)	(1.0)	(0.5)	(<.1)	-	-	-	-	-	-
Deep Draft	8.6	(7.7)	(1.0)	(0.5)	(<.1)	-	-	-	(<0.1)	(<0.1)	(0.2)

33876 Note: The "Shallow" category includes both the Columbia-Snake Shallow category, which refers to traffic that
33877 traveled on both the Columbia and Snake Rivers, and the Columbia Shallow, which presents the impact to traffic
33878 only traveling on the Columbia River.

33879 Source: SCENT modeling.

33880 Table 3-250. for MO4 shows the average annual costs associated with each river segment and
33881 the additional transportation costs for the various flow conditions and draft restrictions
33882 compared to the No Action Alternative. As shown, the difference between these two
33883 alternatives is small, which is consistent with the H&H data used as input into the SCENT.

33884 As shown in Table 3-235., average annual extra transportation costs in the Columbia Shallow
33885 are estimated to be \$15,000 less than the No Action Alternative under MO4. These effects are
33886 within one standard deviation of the No Action Alternative conditions. The average annual
33887 extra transportation costs for transportation in the deep-draft segment are estimated to be
33888 \$300,000 more than the No Action Alternative under MO4 across the industry. These effects
33889 are slightly higher than one standard deviation above the No Action Alternative conditions. The
33890 \$300,000 increase represents less than 0.1 percent of average annual industry operational
33891 costs.

33892

33893 **Table 3-250. Changes in Average Annual Costs of Operations Under Multiple Objective Alternative 4 Relative to No Action**
33894 **Alternative (2019 Dollars), 50 years**

River Segment	Change in Costs Associated with Flow Range Categories				Changes in Costs Associated with Draft Restrictions						
	Low	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft	Total
Columbia-Snake Shallow	–	-\$7,000	-\$1,000	-\$7,000	–	–	–	–	–	–	-\$15,000
Columbia Shallow	–	-\$5,000	-\$4,000	-\$5,000	–	–	–	–	–	–	-\$14,000
Deep Draft	\$576,000	-\$49,000	-\$82,000	-\$123,000	–	–	–	-\$2,000	-\$1,000	-\$5,000	\$315,000
Total	\$576,000	-\$61,000	-\$88,000	-\$135,000	\$0	\$0	\$0	-\$2,000	-\$1,000	-\$5,000	\$286,000

33895 Note: These effects are all within one standard deviation of the current conditions. Costs of operations under normal flow range categories are not anticipated
33896 to be affected under any alternatives and are therefore excluded from the table.

33897 Source: SCENT modeling

33898 **Dredging Operations**

33899 In Regions C and D, increased spill operations from the *Spill to 125% TDG* measure combined
33900 with lower tail water would increase shoaling in the navigation channel at John Day, McNary,
33901 Ice Harbor, Lower Monument and Lower Granite. These effects are not calculated as part of the
33902 transportation cost impact, but instead are estimated based on the River Mechanics analysis,
33903 along with input from operations and cost engineering.

33904 However, in order to avoid or reduce potential adverse impacts to commercial navigation to
33905 negligible impacts, MO4 would result in some additional needs for dredging in the lower Snake
33906 and Columbia Rivers. Over a 50-year period of analysis, annualized dredging costs would
33907 increase by \$1.03 million annually. This is equal to a 1.01 percent increase in annual dredging
33908 costs.

33909 **Commercial Cruise Line Operations**

33910 No changes to cruise ship operations would occur under MO4 because anticipated changes to
33911 river flows and stages would not affect timing or use of the navigation channel.

33912 **Commercial Ferry Operations**

33913 The H&H modeling data indicate that water surface elevations on Lake Roosevelt would be
33914 sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under
33915 MO4 in average water years as well as in dry water years. In larger runoff years, the ferry would
33916 be inoperable for certain periods when Lake Roosevelt is drafted deeper in April and May as
33917 planned under *Planned Draft Rate at Grand Coulee and Updated System FRM Calculation*
33918 measures. These measures would be used to reduce potential flooding effects downstream,
33919 similar to the No Action Alternative. In these “wet” water years, defined as conditions under
33920 the highest 20th percentile forecasted volume at The Dalles Dam, the Inchelium-Gifford Ferry
33921 would not be able to operate for approximately 36 consecutive days in the year under MO4,
33922 which is 9 days more than under the No Action Alternative (a 33 percent increase). Longer
33923 inoperable periods would be expected in wetter years that require more FRM space. This would
33924 result from changes in operations at Grand Coulee Dam under this alternative.

33925 **REGIONAL ECONOMIC EFFECTS**

33926 **Commercial Navigation and Transportation Systems**

33927 Average annual costs to the navigation industry would increase by approximately \$300,000
33928 under MO4. These effects are not likely to result in noticeable effects to regional economies
33929 because they would be distributed throughout the industry, where this increase represents less
33930 than 0.1 percent of normal operating costs.

33931 Commercial Cruise Line Operations

33932 Negligible effects to commercial cruise line operations would occur under MO4. Given this,
33933 effects to regional economies are not anticipated.

33934 Commercial Ferry Operations

33935 The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B
33936 would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out
33937 of the year under MO4 in average water years as well as in dry water years. MO4 would result
33938 in a loss of 9 additional days of operations by the Inchelium-Gifford Ferry in wet years (a 33
33939 percent increase compared to the No Action Alternative), which could represent 3,700 fewer
33940 ferry trips. Longer inoperable periods would be expected in wetter years that require more
33941 FRM space. In those years for those days, expenditures associated with these trips via ferry
33942 would likely be delayed or would not take place in the same locations.

33943 OTHER SOCIAL EFFECTS

33944 Commercial Navigation and Transportation Systems

33945 Average annual costs to the navigation industry would increase by approximately \$300,000
33946 under MO4. These effects are not likely to result in noticeable changes to other social effects,
33947 including changes in air emissions, accident rates, or changes in infrastructure costs under
33948 MO4.

33949 Commercial Cruise Line Operations

33950 Negligible effects to commercial cruise line operations would occur under MO4. Given this,
33951 changes to other social effects are not anticipated under MO4.

33952 Commercial Ferry Operations

33953 The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B
33954 would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out
33955 of the year under MO4 in average water years as well as in wet years. MO4 would result in a
33956 loss of 9 additional days of operations by the Inchelium-Gifford Ferry in wet years (a 33 percent
33957 increase compared to the No Action Alternative). Longer inoperable periods would be expected
33958 in wetter years that require more FRM space. In those years and for those days, travel from
33959 remote communities that use the ferry would not be able to occur. Changes in access by the
33960 remote communities during those days would reduce access to healthcare and educational
33961 facilities, in addition to food and shopping resources. Without the ferry, commuters and others
33962 who need to make the trip must take a 70-mile detour, which adds substantial mileage, gas
33963 costs, time, air emissions, and other effects (Spokesman-Review 2017). Since the ferry is free
33964 and reduces driving time and distance, the loss of ferry service will create additional
33965 transportation costs.

33966 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 4**

33967 MO4 would result in minor increases in average annual costs for deep-draft navigation and
 33968 minor decreases in average annual costs for shallow-draft navigation. The increase in costs for
 33969 deep-draft navigation would result from additional days of low flows requiring an increase in
 33970 the number of tug operations. Overall, this would represent an increase in average annual costs
 33971 of \$300,000 to the industry, representing a less than 0.1 percent increase in costs in
 33972 comparison to the No Action Alternative. Effects to the cruise line industry would be negligible.

33973 The Inchelium-Gifford Ferry would be able to operate 9 days fewer under MO4 than under the
 33974 No Action Alternative in wet years, which could represent 3,700 fewer ferry trips. Longer
 33975 inoperable periods would be expected in wetter years that require more FRM space. During
 33976 those years, minor social welfare effects could be experienced due to the longer inoperable
 33977 period. Minor effects due to loss or redistribution of expenditures associated with the ferry
 33978 trips could also occur. Changes in access to healthcare and educational facilities, in addition to
 33979 food and shopping resources could result in moderate adverse effects. Other ferries would not
 33980 be affected under MO4.

33981 Other than the ferry effects in wet years, effects to commercial navigation and transportation
 33982 systems under MO4 are anticipated to be negligible over the short and long term when
 33983 compared to the No Action Alternative. Table 3-251. provides a summary of the navigation and
 33984 transportation system effects of MO4.

33985 **Table 3-251. Changes in Costs of Commercial Navigation Operations Under Multiple Objective**
 33986 **Alternative 4 Relative to No Action Alternative, over 50 years (2019 Dollars)**

Region	Social Welfare Effects	Regional Economic Effects	OSE
Region B	Minor effects due to decrease in Inchelium-Gifford Ferry operations of an additional 9 days in wet years (for a total of 36 consecutive days), which could represent 3,700 ferry trips. ^{1/} Longer inoperable periods would be expected in wetter years that require more FRM space.	Minor effects due to loss or redistribution of expenditures associated with approximately 3,700 Inchelium-Gifford Ferry trips in wet years. Longer inoperable periods would be expected in wetter years that require more FRM space.	Moderate adverse effects due to reduced access to healthcare and other services of the Inchelium-Gifford for an additional 9 days in wet years. Longer inoperable periods would be expected in wetter years that require more FRM space.
Region C (Snake Shallow)	Negligible effects anticipated to commercial navigation or commercial cruise lines. Average annual costs would slightly decrease.	No effects from commercial navigation, cruise lines, or port operations.	No effects.
Region D (Columbia Shallow)	Negligible effects anticipated to commercial navigation or commercial cruise lines. Average annual costs would slightly decrease.	No effects to cruise lines or port operations.	No effects.

Region	Social Welfare Effects	Regional Economic Effects	OSE
Region D (Deep Draft)	Negligible effects anticipated due to average annual cost increases representing less than 0.1 percent of total costs of navigation operations. No effects to ferries.	Negligible effects to cruise line and port operations. No effects to ferries.	No effects.

33987 1/ "Wet" water years are defined as conditions under the highest 20th percentile forecasted volume at The Dalles
33988 Dam.

33989 **3.10.4 Tribal Interests**

33990 Effects to navigation and transportation resources may affect tribes in the region, depending on
33991 the MO.

33992 The Inchelium-Gifford Ferry operations on Lake Roosevelt would be impacted under all MOs
33993 compared to the No Action Alternative. MO1, MO2, and MO3 would see a reduction of 9 days
33994 in wet years, increasing closure time by 33 percent and MO2 would see a reduction of 2
33995 additional days. This would be an adverse effect to the Confederated Tribes of the Colville
33996 Reservation which relies on the ferry for transportation across the reservoir. Other than these
33997 effects, MO1, MO2, and MO4 would not have substantial changes to navigation or
33998 transportation costs in the study area. MO3, however, would have major effects to the current
33999 commercial navigation system on the Columbia River. Commercial navigation under MO3
34000 would effectively be eliminated at the four LSR projects and all ports on the lower Snake River
34001 would be inaccessible. Shipping costs would also increase for individual shippers. Some tribes
34002 have commented that there are ongoing adverse social and cultural effects as well as
34003 socioeconomic costs to Indian tribes and tribal communities from present and cumulative
34004 effects of the current navigation system, under all MOs. They note that these adverse effects,
34005 along with impairment of Indian treaty-reserved rights, may be reduced under MO3 (Nez Perce
34006 Tribe 2020).

1 **3.11 RECREATION**

2 **3.11.1 Introduction and Background**

3 The Columbia River Basin spans 258,000 square miles and includes a wide variety of ecosystems
4 in a landscape of interspersed mountain ranges and valley floors. The operation of the CRS of
5 dams and reservoirs regulates water flows, creating a mixture of reservoir and in-stream
6 recreational opportunities. These opportunities are as varied as the ecosystems, attracting
7 millions of recreational visitors each year. Additionally, the Pacific Ocean around the mouth of
8 the Columbia River is highly valued as a recreation destination, offering opportunities unique to
9 the coastal environment.

10 Recreational opportunities associated with fish and wildlife are among the most popular
11 activities in this region. The Basin supports fish and wildlife habitat, including wildlife refuges
12 and habitat management units that provide critical waterfowl nesting areas and feeding habitat
13 for upland birds. Salmon, steelhead, sturgeon, walleye, bass, and rainbow trout are popular
14 species for recreational fishing opportunities. Other water-based recreational activities include
15 boating, rafting/paddling, and swimming. Land adjacent to rivers and reservoirs provides
16 opportunities for hiking, hunting, birdwatching and wildlife viewing, photography, picnicking,
17 and camping, among many other activities.

18 Fish of the Columbia River Basin are caught in commercial, recreational, and tribal ceremonial
19 and subsistence fisheries both within the Basin and in the ocean off the coasts of Washington,
20 Oregon, California, British Columbia, and Alaska. Fish are a natural resource of invaluable
21 importance to the tribes of the region, and some tribes have reserved rights to catch fish, as
22 specified in treaties signed with the United States. The Federal government has a trust
23 responsibility to preserve the treaty-reserved rights of these tribes. The Fisheries and Passive
24 Use section of this EIS (Section 3.15) discusses ceremonial and subsistence fishing activities, as
25 well as commercial fishing activities, in more detail.

26 The Columbia River Basin offers a range of developed recreational opportunities. These include
27 hiking trails, marinas, picnic areas, and campgrounds that offer amenities such as restrooms,
28 showers, laundry facilities, water parks, and Wi-Fi. Overnight mooring is also available in some
29 locations. Developed recreation sites are often near capacity on the weekends, especially
30 during the summer months. Holiday weekends such as Memorial Day and Labor Day are
31 especially popular for recreation.

32 Public access is a key component of outdoor recreation, and the Columbia River Basin
33 comprises large blocks of public lands that are not readily available in other parts of the
34 country. Public access laws in the Columbia River Basin vary based on the local, state, tribal, and
35 Federal land management agency. Landforms, as well as other ecological factors and landowner
36 preferences, are determining factors in the availability of public access.

37 Recreation sites include National Recreation Areas, National Wildlife Refuges, National Forests,
38 state parks, county and municipal parks, port-operated marinas and boat launches, private

39 lands, and others. Federal site managers include the Corps, Reclamation, the National Park
40 Service (NPS), the U.S. Bureau of Land Management (BLM), USFWS, and the U.S. Forest Service
41 (USFS). State-managed facilities in Washington, Oregon, Idaho, and western Montana located
42 on both state lands and Reclamation-administered properties are operated by Washington
43 State Parks and Recreation Commission (WSPRC) and WDFW; Oregon Parks and Recreation
44 Department (OPRD) and ODFW; Idaho Department of Parks and Recreation (IDPR) and IDFG;
45 and MFWP, respectively. At Lake Roosevelt, the Spokane Tribe of Indians and the Confederated
46 Tribes of the Colville Reservation manage recreation in the parts of Lake Roosevelt National
47 Recreation Area that fall within their respective reservation boundaries. This tribal
48 management of recreation is one of the outcomes of the Lake Roosevelt Cooperative
49 Management Agreement of 1990.

50 The level of recreation use, particularly for water-based recreation, depends on specific factors
51 and site characteristics. These include the flows and elevations of rivers and reservoirs (water-
52 based access); the number and quality of facilities at a site (e.g., campgrounds, restrooms, or
53 marinas); proximity to population centers, which affects the travel cost and time to reach a site;
54 water quality (e.g., clarity and cleanliness); availability of fish (i.e., abundance and types of
55 species), which influences catch rates for anglers; crowding; the range of activities that can be
56 pursued; and the amenities and aesthetic quality of the site/area.

57 Water levels fluctuate throughout the year, and between years, depending on the level of snow
58 and rainfall in the region. In a regulated system, generally, reservoir levels are lowered in the
59 winter in preparation for collection of spring snowmelt, and are filled again by the end of the
60 spring freshet. In low precipitation years, the spring refill may not be as successful, leaving
61 reservoir levels low throughout the summer. Low reservoir levels and river flows can negatively
62 impact the accessibility of recreational boat ramps and rafting opportunities.

63 Recreational activities are valued by recreationists. The economic value of recreation is the
64 difference between the maximum amount a recreationist would be willing to pay to participate
65 in a recreational activity and the actual cost of participating in that activity. This is referred to
66 by economists as *consumer surplus* or *net economic value*. Put simply, this is a recreationist's
67 value of a trip after all expenses have been paid. For example, if a recreationist is willing to pay
68 \$105 to go rafting on the lower Snake River, but only incurs \$75 of expenses, they receive \$30
69 of consumer surplus value from their trip.

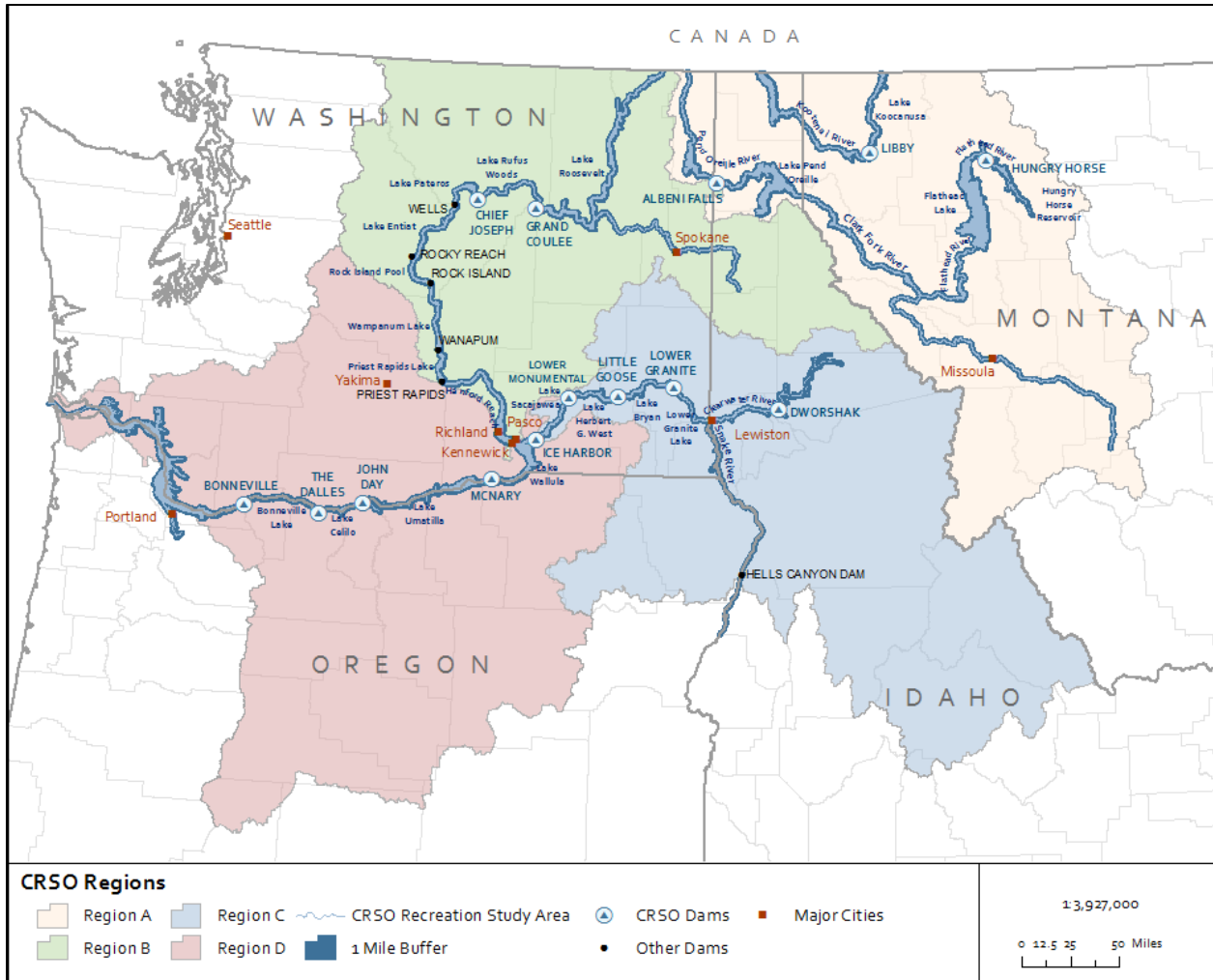
70 Recreational use of the Columbia River Basin also produces economic activity. As visitors travel
71 to and from recreation areas, they spend money in local communities on food, gas, lodging, and
72 other trip-related expenses. Visitors who live outside the Columbia River Basin stimulate
73 economic activity and inject new money into local economies, supporting jobs and income for
74 residents. For example, if a non-local recreationist spends \$75 on gas, food, and other supplies
75 to go rafting on the lower Snake River, these expenditures provide sales for businesses in the
76 region. In turn, these businesses make purchases from other firms in the region to support their
77 operations, and employees of these firms make additional purchases with their wages. The
78 summation of these effects represents the total economic impact of recreational activities to

79 the region, which can be measured in terms of sales (spending), jobs, income, and value added,
80 although other measures may be used. Regional economic impacts are estimated by tracing
81 expenditures for recreation through the regional economy (e.g., using an input-output model
82 such as IMPLAN).

83 In addition to the economic benefits described above, recreation can positively impact the
84 physical, mental, and social health of individuals and their communities (California State Parks
85 2005). These types of effects are described and evaluated for recreation under the other social
86 effects analysis. Recreation benefits physical health by keeping people active and reducing
87 obesity and the risk of chronic disease. It benefits mental health by relieving stress, reducing
88 depression, and improving quality of life. With respect to strengthening communities,
89 recreation supports family interactions and can build cultural and socioeconomic diversity, as
90 public recreation areas are generally free to access or have low fees (California State Parks
91 2005).

92 The presence of dams and system operations have had long-term adverse effects on the
93 recreational opportunities for area tribes, particularly for fishing and hunting. Section 3.16,
94 *Cultural Resources*, and Section 3.17, *Indian Trust Assets, Tribal Perspectives, and Tribal*
95 *Interests*, provide additional information about ongoing effects as well as unique effects of MOs
96 on tribal subsistence activities and cultural practices.

97 The general study area for this section is further defined into regions using the Columbia River
98 watersheds in which the CRS projects are located, which are identified as Regions A to D
99 (Figure 3-221). Within the general area, the recreation analysis focuses on recreational lands
100 and activities located within 1 mile of the mainstem rivers, since these lands and activities are
101 likely to be affected directly by MOs. The analysis also addresses impacts associated with
102 potential changes to visitation to other areas that may result from MOs. The county-based
103 study area for the regional economic effects evaluation is described in Section 3.11.3.1.



104
 105 **Figure 3-221. Areas of Analysis for Recreation**

106 **3.11.2 Affected Environment**

107 This section describes the existing condition of recreational resources that may be affected by
 108 the alternatives under consideration:

- 109 • Section 3.11.2.1, *Recreation Areas*, summarizes recreation areas in the Columbia River Basin
 110 and adjacent Pacific Ocean. The discussion is organized by region. A brief summary of site
 111 characteristics and facilities is provided for major sites, along with a description of the
 112 recreational activities pursued.
- 113 • Section 3.11.2.2, *Recreational Visitation*, provides recreational visitation statistics from
 114 recent years for the sites described in Section 3.11.2.1. The environmental consequences
 115 section (and Appendix M, *Recreation*) assesses potential changes in visitation that may
 116 occur due to MOs and associated changes in economic benefits.

117 **3.11.2.1 Recreation Areas**

118 This section provides a description of recreation areas in the Columbia River Basin. The study
119 area is organized by CRS region and then by river reach within each region. A brief summary of
120 characteristics and facilities is provided for major recreation areas, along with a description of
121 the recreational opportunities available.

122 The summary of recreation areas focuses on sites managed by Federal and state agencies,
123 primarily at reservoir recreation areas. Much of the recreation in the region occurs at these
124 sites and visitation data is readily available from these agencies. Further, the summary focuses
125 on recreation sites at reservoirs or on or near rivers in the Columbia River Basin. There are at
126 least 550 on- or near-water recreation access points managed by Federal and state agencies
127 within 1 mile of the mainstem rivers in the Columbia River Basin, which include boat launches,
128 campgrounds, interpretive centers, and parks.

129 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

130 Region A spans parts of eastern Washington, northern Idaho, and northwestern Montana. It
131 includes three Federal projects: Albeni Falls Dam, Libby Dam, and Hungry Horse Dam. Although
132 the Columbia River does not flow through this region, it includes many Columbia River
133 tributaries, including the Pend Oreille, Clark Fork, Flathead, and Kootenai Rivers. The region
134 consists of the following reaches which include both CRS projects and other regionally
135 important projects:

- 136 • Kootenai River between the U.S.-Canada border and Libby Dam/Lake Koocanusa
- 137 • South Fork Flathead River above Flathead Lake and Hungry Horse Dam and Reservoir
- 138 • Clark Fork River, Flathead River below Flathead Lake, and Flathead Lake
- 139 • Pend Oreille River and Lake Pend Oreille

140 The region contains at least 124 recreation access points on or near the mainstem rivers and
141 reservoirs that are managed by Federal and state agencies. Table 3-252 summarizes land
142 ownership for protected lands located within 1 mile of the mainstem rivers in Region A, many
143 of which are accessible to recreationists. The USFS manages the largest acreage within 1 mile of
144 the major tributaries of the Columbia River, managing approximately 50 percent of this area.
145 The area includes portions of the Colville National Forest, Idaho Panhandle National Forests,
146 Kootenai National Forest, Lolo National Forest, Flathead National Forest, and Beaverhead-
147 Deerlodge National Forest. This region also includes lands of four Indian tribes: Kootenai Tribe ,
148 CSKT (Flathead Reservation), Kalispel Tribe, and Coeur D'Alene Tribe.

149 **Table 3-252. Federal, Tribal, and Other Protected Lands in Region A by Land Manager**

Land Manager	Acres Within 1 mile of Mainstem Rivers	Percent (%) of Total
Federal	473,087	59
<i>BLM</i>	9,966	1
<i>DOD</i>	22	0
<i>NPS</i>	1,943	0
<i>NRCS</i>	4,539	1
<i>Reclamation</i>	22,929	3
<i>USFS</i>	426,120	53
<i>USFWS</i>	7,568	1
Tribal	228,228	28
State	71,024	9
County/Regional/Local	985	0
Private/NGO	28,148	4
Other	1,611	0
Total Protected Lands	803,082	100

150 Note: DOD = U.S. Department of Defense; NGO = non-governmental organization.

151 Source: USGS Gap Analysis Program (GAP), May 2016 Protected Areas Database of the United States (PAD-US),
152 Version 1.4 Combined Feature Class

153 Travel to recreation access points along these rivers is supported by a network of mostly rural
154 highways. Local recreational visitors come from Coeur d’Alene, Idaho; Kalispell and Missoula,
155 Montana; and the surrounding areas. Lake Pend Oreille, Flathead Lake, Lake Koochanusa, and
156 the river stretches in between, provide opportunities for fishing, boating, paddling, swimming,
157 windsurfing, hunting, hiking, wildlife viewing, picnicking, and camping.

158 **Kootenai River Between the U.S.-Canada Border and Libby Dam/Lake Koochanusa**

159 The Kootenai River is one of the largest tributaries of the Columbia River. Libby Dam, located in
160 Montana, was constructed near the confluence of the Kootenai and Columbia Rivers. Although
161 the lake is relatively undeveloped, recreational activities such as boating, camping, fishing,
162 hiking, and picnicking are popular. The Corps operates Libby Dam and its visitor center, a
163 campground, and a boat ramp on Lake Koochanusa while USFS operates and manages all other
164 recreational facilities along the reservoir. For Lake Koochanusa, recreation impacts in Canada are
165 anticipated to be similar to those in the United States for all MOs.

166 **Flathead River Above Flathead Lake and Hungry Horse Dam and Reservoir**

167 Above Flathead Lake, the south fork of the Flathead River is impounded by Hungry Horse Dam.
168 The Hungry Horse Visitor’s Center and Dam, which forms the Hungry Horse Reservoir, are
169 operated by Reclamation; however, administration of the recreation opportunities on the
170 reservoir and the surrounding lands have been jurisdictionally transferred to USFS. The

171 reservoir is approximately 34 miles long with 170 miles of shoreline. Located about 15 miles
172 south of Glacier National Park, the reservoir is narrow and wedged between mountains of the
173 Northern Rockies. The lake and adjacent area provide access for recreational fishing, boating,
174 swimming, hiking, camping, and other activities. The area offers both primitive and developed
175 recreational opportunities.

176 **Clark Fork River, Flathead River Below Flathead Lake, and Flathead Lake**

177 Flathead Lake in northwestern Montana spans 200 square miles and has 185 miles of shoreline.
178 The lake is bordered by communities including Polson and Bigfork, Montana, and the Flathead
179 Indian Reservation on the southern half of the lake. The portion of the lake overlapping the
180 Flathead Indian Reservation is managed by the CSKT, while other sections of the lake are
181 managed by MFWP. Recreational activities on the lake include fishing, boating, camping,
182 swimming, hiking, biking, skiing, snowmobiling, and horseback riding. Note that Flathead Lake is
183 not technically a Federal reservoir, however water surface elevations at this popular recreation
184 destination are affected by releases from Hungry Horse Dam.

185 **Pend Oreille River and Lake Pend Oreille**

186 Lake Pend Oreille, a natural lake enlarged when the Corps constructed Albeni Falls Dam, is
187 sourced from the lower Clark Fork and Pack Rivers and is the largest and deepest lake in Idaho.
188 The 43-mile-long lake has a maximum depth of 1,200 feet and 111 miles of shoreline. Lake Pend
189 Oreille is surrounded by a mountainous landscape. Dozens of developed recreation sites on the
190 lake host recreational activities such as fishing, boating, sailing, paddling, camping, swimming,
191 and waterskiing in the summer and cross-country skiing and snowmobiling in the winter. Other
192 recreational activities along the lake include sightseeing, wildlife viewing, picnicking, scuba
193 diving, hunting, hiking, and horseback riding. Campgrounds are managed by the Corps, USFS,
194 IDFG, IDPR, and various cities, counties, and private concessionaires. Boat accessibility on Lake
195 Pend Oreille and the Pend Oreille River is largely achieved via private docks (more than 2,000)
196 and commercial and public marinas. Accessibility and usability of fixed docks and swimming
197 areas, fishing conditions, and lake aesthetics are sensitive to changes in lake elevations.

198 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

199 Region B includes the Columbia River between the Tri-Cities (Richland, Kennewick, and Pasco)
200 in Washington and the U.S.-Canada border. There are two CRS projects in this region, the Grand
201 Coulee and Chief Joseph Dams, and several smaller dams managed by other entities. A
202 prominent feature in this region is the Lake Roosevelt National Recreation Area. Created in
203 1941 with the construction of Grand Coulee Dam, it attracts the most recreational visitation in
204 Region B. The river is accessible using rural highways throughout this region. The Hanford
205 Reach, located below Priest Rapids Dam, is also a unique feature in this region because it is the
206 only free-flowing reach on the Columbia River below Lake Roosevelt and is bordered almost
207 entirely by wildlife refuges and open space. While public access is limited in the Hanford
208 Nuclear Reservation, habitat for fish and wildlife provide abundant fishing, hunting, and wildlife

209 viewing opportunities. The region consists of several CRS projects as well as some non-CRS
210 projects and their associated lakes and reaches:

- 211 • Grand Coulee Dam and Lake Roosevelt
- 212 • Chief Joseph Dam and Rufus Woods Lake
- 213 • Wells Dam and Lake Pateros
- 214 • Rocky Reach Dam and Lake Entiat
- 215 • Rock Island Dam and reservoir
- 216 • Wanapum Dam and Wanapum Lake
- 217 • Priest Rapids Dam and Priest Rapids Lake
- 218 • The Hanford Reach below Priest Rapids Dam

219 The region encompasses at least 89 recreation access points on or near water that are managed
220 by Federal and state agencies. Table 3-253 summarizes land ownership for protected lands
221 located within 1 mile of the Columbia River in Region B, many of which are accessible to
222 recreationists. Much of the area in Region B is managed by tribes, including lands of the
223 Spokane Tribe of Indians and the Confederated Tribes of the Colville Reservation. The NPS
224 manages approximately one-quarter of protected areas within 1 mile of the mainstem
225 Columbia River, primarily associated with Lake Roosevelt National Recreation Area. The
226 Hanford Reach National Historic Monument is also in this region.

227 **Table 3-253. Federal, Tribal, and Other Protected Lands in Region B by Land Manager**

Land Manager	Acres Within 1 mile of Mainstem Rivers	Percent (%) of Total
Federal	134,202	34
<i>BLM</i>	<i>25,122</i>	<i>6</i>
<i>DOD</i>	<i>15,969</i>	<i>4</i>
<i>DOE</i>	<i>54,564</i>	<i>14</i>
<i>NRCS</i>	<i>903</i>	<i>0</i>
<i>Reclamation</i>	<i>218</i>	<i>0</i>
<i>USFS</i>	<i>4,750</i>	<i>1</i>
<i>USFWS</i>	<i>32,676</i>	<i>8</i>
Tribal	173,104	44
State	75,798	19
County/Regional/Local	9,937	3
Private/NGO	49	0
Other	57	0
Total Protected Lands	393,147	100

228 Source: USGS GAP, May 2016, PAD-US, Version 1.4 Combined Feature Class

229 Region B is relatively rural and most recreation sites are located at the Federal projects.
230 Spokane, Washington is the most populated community in this region. Large tributaries in this
231 region include the Yakima, Wenatchee, Entiat, Methow, Okanogan, and Spokane Rivers. A
232 range of recreational activities are pursued in this region.

233 **Grand Coulee Dam and Lake Roosevelt**

234 Lake Roosevelt spans over 150 miles from Grand Coulee Dam to the U.S.-Canada border and
235 features 600 miles of shoreline. The Colville National Forest, Colville Indian Reservation,
236 Spokane Indian Reservation, and historic Fort Spokane are adjacent to the lake. Grand Coulee
237 Dam is operated by Reclamation. Recreational access is managed by NPS, Confederated Tribes
238 of the Colville Reservation, and the Spokane Tribe of Indians. Lake Roosevelt National
239 Recreation Area, the portion of the lake managed by NPS, receives much of the annual
240 visitation; mostly for camping, fishing, swimming, boating, and picnicking. Common sport fish
241 caught in Lake Roosevelt include rainbow trout, kokanee, northern pike, burbot, white
242 sturgeon, walleye, and perch. Access to the lake for recreation is restricted during drawdowns,
243 and the minimum usable water elevations vary across boat ramps at the reservoir. The
244 landscape surrounding Lake Roosevelt is relatively undeveloped except for a few farms and
245 small communities. Visitors enjoy views of valleys and mountains beyond the lake, as well as
246 rolling hills and undeveloped shoreline covered in rich coniferous forest. The Grand Coulee
247 laser light show and dam tours are also popular visitor attractions.

248 **Chief Joseph Dam and Rufus Woods Lake**

249 Chief Joseph Dam, a Corps facility located about 2 miles upriver from Bridgeport, Washington,
250 forms Rufus Woods Lake. The lake spans 51 miles up to Grand Coulee Dam. The surrounding
251 landscape is rugged, featuring a canyon and granite cliffs, providing visitors with opportunities
252 to hike, hunt, and view wildlife. Other recreational activities include boating, fishing
253 (particularly for sturgeon and burbot), swimming, and camping. The Confederated Tribes of the
254 Colville Reservation operate a net pen program, which contributes 50,000 to 70,000 triploid
255 trout to the region's fishery annually.

256 **Priest Rapids Dam and Priest Rapids Lake to Wells Dam and Lake Pateros**

257 The reaches between Priest Rapids Dam (RM 397) and Chief Joseph Dam (RM 545) along the
258 Columbia River are separated by four run-of-river dams: Wanapum Dam, Rock Island Dam,
259 Rocky Reach Dam, and Wells Dam. Rock Island and Rocky Reach Dams are highly developed,
260 featuring visitor centers, fish viewing rooms, restrooms, picnic shelters, and more. Scenic
261 driving, featuring views of Cascade Range, cliffs along the river canyon, and fruit orchards, is the
262 most popular recreational activity in the region (DOE, Corps, and Reclamation 1995). Water-
263 related recreation such as fishing, boating, and swimming also occurs in the area.

264 **Hanford Reach Below Priest Rapids Dam**

265 The Hanford Reach between Priest Rapids Dam and Lake Wallula is the only free-flowing reach
266 below Lake Roosevelt, and is located north of the Tri-Cities area upstream of McNary Dam. The
267 landscape consists of shrub steppe communities, including sand dunes and native plant
268 communities with views of nearby mountains. Much of the land is undeveloped, aside from the
269 Hanford Site for which the reach is named. The cities of Pasco, Kennewick, and Richland,
270 Washington; Benton County; WDFW; USFWS; and the Corps manage recreational opportunities
271 within the reach. Vernita Bridge Water Access Site, operated by the USFWS, is a highly used
272 primitive boat access point within the reach. Other unpaved boat ramps within the reach
273 provide additional access for fishing, wildlife viewing, boating, and hunting. Fishing is the main
274 attraction along this reach with anadromous fish, sturgeon, and walleye commonly targeted.

275 **REGION C – DWORSHAK, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS**

276 Region C includes the Snake River from its mouth at the Columbia River to Hells Canyon, as well
277 as the Clearwater River from its mouth on the Snake River at Lewiston, Idaho, to Dworshak
278 Dam. The four lower Snake River projects are located below Lewiston, Idaho, which is the most
279 populated community in this region. Rural highways run adjacent to or near the water in Region
280 C. Within the Wallowa-Whitman National Forest south of Lewiston, Idaho, the Snake River is
281 designated a Wild and Scenic River up to Hells Canyon Dam. River reaches within Reach C that
282 are potentially affected by changes in CRS operation include the following:

- 283 • Clearwater River (including North Fork) and Dworshak Dam/Reservoir
- 284 • Snake River below Hells Canyon Dam
- 285 • Lower Granite Dam and Lower Granite Lake
- 286 • Little Goose Dam and Lake Bryan
- 287 • Lower Monumental Dam and Lake Herbert G. West
- 288 • Ice Harbor Dam and Lake Sacajawea

289 Region C encompasses at least 129 recreation access points on or near water that are managed
290 by Federal and state agencies and private (for profit) entities. Table 3-254 summarizes land
291 ownership for protected lands located within 1 mile of the Snake and Clearwater Rivers in
292 Region C, many of which are accessible to recreationists. The USFS manages more than half (58
293 percent) of protected lands in this area, and includes portions of a number of national forests.
294 In addition to Wallowa-Whitman National Forest, the area includes portions of Hells Canyon
295 Recreation Area and Wilderness Area, the Nez-Perce Clearwater National Forest, and Payette
296 National Forest, among others. The Corps manages the lakes behind all of the Snake River dams
297 in this region. Over 73,000 acres of Nez Perce Tribe lands are also located in the areas within 1
298 mile of the Snake River.

299 Population density throughout much of Region C is low and the riverbanks are often steep and
300 rugged. Recreation sites vary from developed state and Federal lands to boat launches with

301 limited amenities. Large tributaries of the Snake River in this region include the Palouse,
302 Clearwater, Grande Ronde, and Salmon Rivers. A range of recreational activities are pursued in
303 this region. Rafting is a particularly important use in this region relative to others, especially in
304 Hells Canyon National Recreation Area (HCNRA).

305 **Table 3-254. Federal, Tribal, and Other Protected Lands in Region C by Land Manager**

Land Manager	Acres Within 1 mile of Snake and Clearwater Rivers	Percent (%) of Total
Federal	104,196	43
<i>BLM</i>	<i>11,836</i>	<i>5</i>
<i>USFS</i>	<i>92,208</i>	<i>38</i>
<i>USFWS</i>	<i>153</i>	<i>0</i>
Tribal	73,014	30
State	63,669	26
Private/NGO	7	0
Other	152	0
Total Protected Lands	241,037	100

306 Source: USGS GAP, May 2016, PAD-US, Version 1.4 Combined Feature Class

307 **Clearwater River and Dworshak Dam/Reservoir**

308 The Clearwater River empties into the lower Snake River at Lewiston, Idaho. The Dworshak
309 Dam, operated by the Corps, is located at RM 1.9 on the north fork of the Clearwater River on
310 the Nez Perce Reservation, and about 50 miles east of Lewiston, Idaho. The landscape
311 surrounding the 717-foot dam is forested and mountainous, attracting campers, hunters, and
312 fishers. The reservoir behind the dam provides excellent boating and waterskiing, with fixed
313 swim docks and houseboat buoys. Two mitigation hatcheries, Dworshak Hatchery and
314 Clearwater Hatchery, are located downstream of the dam on the north fork of the Clearwater
315 River. These hatcheries produce steelhead, spring Chinook salmon, summer Chinook salmon,
316 and coho salmon to support regional fisheries. The Dworshak Reservoir also offers unique, boat
317 access campsites along the length of the reservoir, though most boat ramps are concentrated
318 on the downstream end of the reservoir.

319 **Lower Granite Dam and Lower Granite Lake**

320 Lower Granite Dam is a Corps facility in southeastern Washington near the Idaho border. Lower
321 Granite Lake extends 39 miles behind the dam to Lewiston, Idaho. The recreation areas along
322 the lake are managed by the Corps and offer an array of outdoor activities, including walking
323 trails, fishing, boating, hunting, and more. Lower Granite Dam also provides wildlife
324 observation, including fish viewing rooms. Many recreation sites provide picnic areas,
325 campsites, and boat ramps.

326 **Little Goose Dam and Lake Bryan**

327 Little Goose Lock and Dam, a Corps facility 70 miles upriver from the mouth of the Snake River,
328 forms Lake Bryan. The landscape includes open vistas, steep canyon walls, sand dunes, and few
329 trees. Developed sites along Lake Bryan include two that are leased from the Corps by the State
330 of Washington and one that is leased by the Port of Whitman County. Recreation development
331 at Lake West is also limited, largely due to the high cliffs that surround the reservoir. Recreation
332 sites are primarily managed and operated by the Corps, though some are operated by other
333 entities. Popular activities in the area include camping, hunting, boating, swimming,
334 waterskiing, fishing, and wildlife viewing. Facilities along Little Goose Dam and Lake Bryan
335 include campgrounds, boat ramps, and swimming areas.

336 **Lower Monumental Dam and Lake Herbert G. West**

337 Lower Monumental Dam and Lake West, a Corps facility, is situated near the confluence of the
338 Snake and Palouse Rivers in southeastern Washington. The lake extends 28 miles east to Little
339 Goose Dam. Visitors walk, hunt, picnic, view wildlife, and camp in the area. Lake West offers
340 water activities such as fishing and boating.

341 **Ice Harbor Dam and Lake Sacajawea**

342 Ice Harbor Dam and Lake Sacajawea is a Corps facility on the lower Snake River, about 45 miles
343 northwest of Walla Walla, Washington. The open landscape provides the public with
344 opportunities to walk, hunt, and camp. The lake itself is popular for boating, fishing, swimming,
345 and waterskiing. Wildlife observation opportunities include birdwatching at the adjacent
346 wildlife refuge or habitat management units. The visitor center at the dam provides opportunity
347 to see salmon migrate upstream.

348 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

349 Region D includes the Columbia River from the mouth at the Pacific Ocean to the Tri-Cities area
350 in Washington. A prominent feature in this region is the Columbia River Gorge National Scenic
351 Area, which is managed by the USFS. As the largest national scenic area in the United States, it
352 is 80 miles long and the surrounding basalt canyon is up to 4,000 feet deep in some locations.
353 Highway 84 runs along the river in the gorge and provides the only sea level route through the
354 Cascade Range. The gorge is among the most popular areas within the Columbia River Basin,
355 and draws visitors from throughout the United States. In the western portion of the gorge (west
356 of Hood River, Oregon), the Columbia River gradually widens and the landscape is characterized
357 by rolling hills and low-lying valleys. The most populated communities in this region include the
358 areas around Portland, Oregon, and Vancouver, Washington. The river in this region has several
359 reaches, which consist of the four lower Columbia River projects:

- 360 • McNary Dam and Lake Wallula
361 • John Day Dam and Lake Umatilla

- 362 • The Dalles Dam and Lake Celilo
- 363 • Bonneville Dam and Lake Bonneville
- 364 • Downstream of Bonneville Dam

365 Large tributaries of the Columbia River in this region include the Cowlitz, Lewis, Willamette,
 366 White Salmon, Hood, Deschutes, John Day, Umatilla, and Walla Walla Rivers. The reaches along
 367 the Columbia River in this region include a series of dams and reservoirs with numerous
 368 developed recreation sites. A substantial portion of water-based recreation in the Columbia
 369 River Basin takes place in the reservoirs created by the Bonneville, The Dalles, John Day, and
 370 McNary Dams (DOE, Corps, and Reclamation 1995). Dozens of access points are found along
 371 these reservoirs.

372 The region encompasses at least 215 access points on or near water that are managed by
 373 Federal and State agencies. Table 3-255 summarizes land ownership for protected lands located
 374 within 1 mile of the Columbia River in Region D, many of which are accessible to recreationists.
 375 The USFS manages the largest share of protected lands in this region, with USFWS and the
 376 Corps also managing a substantial share of lands. In addition to the Columbia River Gorge
 377 National Scenic Area, a portion of the Lewis and Clark National Historic Trail is in this region.

378 **Table 3-255. Federal, Tribal, and Other Protected Lands in Region D by Land Manager**

Land Manager	Acres Within 1 mile of Lower Columbia River	Percent (%) of Total
Federal	119,710	65
<i>BLM</i>	<i>8,580</i>	<i>5</i>
<i>DOD</i>	<i>70</i>	<i>0</i>
<i>DOE</i>	<i>603</i>	<i>0</i>
<i>NPS</i>	<i>164</i>	<i>0</i>
<i>NRCS</i>	<i>526</i>	<i>0</i>
<i>USFS</i>	<i>40,047</i>	<i>22</i>
<i>USFWS</i>	<i>69,721</i>	<i>38</i>
Tribal	7,700	4
State	33,935	19
County/Regional/Local	19,266	11
Private/NGO	1,005	1
Other	1,676	1
Total Protected Lands	183,294	100

379 Source: USGS GAP, May 2016, PAD-US, Version 1.4 Combined Feature Class

380 **McNary Dam and Lake Wallula**

381 McNary Dam and Lake Wallula are operated and managed by the Corps. The dam sits on the
 382 Columbia River at RM 292 near the Tri-Cities area and the lake extends to about RM 335. Public

383 recreation on the lake include water sports, boating, wildlife viewing, fishing and picnicking.
384 Lake Wallula, its 242 miles of shoreline, and its surrounding landscape is a mixture of parks,
385 agriculture, and private developed land. The USFWS operates the McNary National Wildlife
386 Refuge near the confluence of the Columbia River with the Snake River. A number of developed
387 marinas and boat launches provide boating access near the Tri-Cities area.

388 **John Day Dam and Lake Umatilla**

389 The John Day Dam, roughly equidistant from Portland, Oregon, and the Tri-Cities area in
390 Washington, is a Corps facility at RM 216 that forms the 76-mile-long Lake Umatilla. Umatilla
391 National Wildlife Refuge is located on Lake Umatilla, and provides opportunities for hunting,
392 fishing, and wildlife viewing. Campgrounds along the lake operated by the Corps are open
393 seasonally. Recreation areas along the lake support boating, swimming, camping, fishing,
394 hunting, walking, windsurfing, and other activities.

395 **The Dalles Dam and Lake Celilo**

396 The Dalles Dam, operated by the Corps, is located at RM 192 and forms Lake Celilo. The lake is
397 approximately 24 miles long. The recreation areas around The Dalles Dam and Lake Celilo offer
398 views of several notable mountain peaks, including Mount Hood. Amenities include walking
399 trails, picnic areas, campgrounds, and boat ramps. The dam and grounds are operated and
400 managed by the Corps.

401 **Bonneville Dam and Lake Bonneville**

402 Bonneville Lock and Dam, a National Historic Landmark operated by the Corps, is located within
403 the Columbia River Gorge National Scenic Area at RM 146. Lake Bonneville extends 46 miles
404 east to The Dalles Dam. The area is also maintained and operated for recreation by the Corps.
405 The three visitor's centers at Bonneville Dam offer tours of the powerhouse, hatchery, and the
406 sturgeon center, and provide interpretive information about regional history and cultures. Lake
407 Bonneville and the surrounding area are used for picnicking, sightseeing, wildlife viewing,
408 fishing, boating, waterskiing, windsurfing, and other activities. Recreation sites along the
409 lakeshore offer amenities including campgrounds, swimming beaches, and recreational trails.

410 **Downstream of Bonneville Dam**

411 The Columbia River is free flowing below Bonneville Dam and is tidally influenced. Given these
412 characteristics, along with close proximity to the Pacific Ocean and major population centers,
413 including Portland, Oregon, recreational fishing and boating are popular uses of the river. Other
414 important activities include paddling, swimming, windsurfing, hunting, hiking, wildlife viewing,
415 and camping. There are numerous city, county, state, and Federal lands in this region that have
416 been developed for recreation use. A number of small businesses are dependent on the
417 recreational draw of the area including restaurants, wineries, and specialty shops. The
418 Willamette River, which empties into the Columbia just north of Portland, Oregon, is a large
419 tributary in this reach.

420 The Pacific Ocean off the coasts of Oregon and Washington provides recreational opportunities
421 for visiting the beach, crabbing, clamming, sunbathing, sightseeing, hiking, and fishing.

422 Columbia River Basin anadromous fish support recreational ocean fishing. Fishing for these
423 species occurs primarily by private boat and charter vessels, though some recreational fishing
424 effort occurs from sandy beaches, jetties, piers, and other features along the shoreline (NMFS
425 2014b; TRG 2015). NMFS manages recreational fishing in Federal waters (3 to 200 miles from
426 shore) while the states manage ocean fishing in their coastal waters (0 to 3 miles from shore).

427 **3.11.2.2 Recreational Visitation**

428 This section presents recreational visitation estimates from recent years for the sites described
429 in Section 3.11.2.1, *Recreation Areas*. This data was compiled with assistance from Federal and
430 state agencies. These agencies estimate visitation using a range of methods, including direct
431 counts by field staff, counts by automated traffic and trail counters, permit and fee information,
432 and professional judgment. Visitor surveys are used to understand trip characteristics, such as
433 group size, activities, and length of stay.

434 Due to gaps in existing information, visitation estimates are not available for all sites.¹
435 Additional details on available recreational visitation data for the Basin is provided in Appendix
436 M Recreation.

437 Table 3-256 presents available annual visitation estimates for 2017 and 2018 and the
438 distribution of monthly visitation for 2018. Consistent visitation data for years prior to 2017 is
439 not available from all Federal and state agencies. Further, based on conversations with the H&H
440 Team and recreation managers, 2017 and 2018 represent relatively typical years in terms of
441 water levels and recreational visitation. Across the Basin, total recreational visitation at sites
442 within 1 mile of the mainstem rivers, including water- and land-based use at reservoirs and
443 river reaches, exceeds 13 million visits annually, with most visitation occurring in summer
444 months.² The top three most-visited sites/reaches in recent years with available data are
445 McNary Dam and Lake Wallula, Lower Granite Dam and Lower Granite Lake, and Bonneville
446 Dam and Lake Bonneville.

447 Some of the most commonly pursued activities in the region include fishing, sightseeing,
448 boating, swimming, picnicking, and camping. Table 3-257 summarizes the distribution of
449 recreation use at reservoirs/river reaches where such data is available. The most recent
450 information is presented, which is from 2016.

¹ Specifically, estimates for near-water sites managed by the USFS are only available at Hungry Horse Reservoir and only for a small portion of the total recreation sites on the reservoir. Estimates are missing from USFWS for select National Wildlife Refuges. Visitation data for sites that are not managed by Federal and state agencies is not included in the summary that follows. It is expected that fluctuations in visitor use and activities would be mirrored at sites managed by local agencies and private land owners.

² Because regional visitation data from Federal and state agencies is more comprehensively collected for reservoirs and is limited for sections of river between reservoirs, total estimated visitation primarily reflects reservoir-based recreation.

451 **Table 3-256. Available Recreational Visitation Data for Columbia River Basin Reservoirs and River Reaches**

Reservoir/River Reach	2018 Monthly Recreational Visitation as a Percentage of Total Site Visitation ^{1/}												Annual Total Site Visits (Thousands of Visits)		
	January	February	March	April	May	June	July	August	September	October	November	December	2017 Total	2018 Total	2017-2018 Average
Kootenai River between the U.S.-Canada border and Libby Dam and Lake Koocanusa	2%	2%	2%	4%	18%	17%	18%	16%	13%	6%	2%	1%	189	198	193
South Fork Flathead River above Flathead Lake and Hungry Horse Dam and Reservoir	0%	0%	0%	0%	5%	15%	43%	28%	9%	0%	0%	0%	6	9	7
Clark Fork River, Flathead River below Flathead Lake, and Flathead Lake	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	309	323	316
Pend Oreille River and Lake Pend Oreille	1%	2%	1%	4%	13%	14%	26%	20%	12%	4%	2%	2%	975	1,020	997
Region A Total	1%	2%	2%	4%	14%	15%	24%	19%	12%	5%	2%	2%	1,478	1,550	1,514
Grand Coulee Dam and Lake Roosevelt	4%	4%	5%	6%	9%	13%	23%	18%	9%	4%	2%	2%	1,304	1,277	1,291
Chief Joseph Dam and Rufus Woods Lake	4%	4%	6%	8%	9%	13%	15%	12%	10%	8%	5%	5%	412	340	376
Wells Dam and Lake Pateros	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Rocky Reach Dam and Lake Entiat	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Rock Island Dam and Pool	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wanapum Dam and Wanapum Lake	2%	2%	6%	9%	12%	15%	17%	14%	12%	7%	3%	2%	322	331	327
Priest Rapids Dam and Priest Rapids Lake	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
The Hanford Reach below Priest Rapids Dam	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Reservoir/River Reach	2018 Monthly Recreational Visitation as a Percentage of Total Site Visitation ^{1/}												Annual Total Site Visits (Thousands of Visits)		
	January	February	March	April	May	June	July	August	September	October	November	December	2017 Total	2018 Total	2017-2018 Average
Region B Total	4%	4%	5%	7%	10%	13%	21%	16%	10%	5%	3%	2%	2,038	1,948	1,993
Clearwater River and Dworshak Dam and Reservoir	2%	3%	5%	7%	12%	16%	20%	13%	8%	8%	4%	2%	489	430	459
Lower Granite Dam and Lower Granite Lake	5%	5%	6%	9%	11%	10%	11%	13%	7%	12%	6%	4%	1,938	1,882	1,910
Little Goose Dam and Lake Bryan	3%	3%	5%	4%	10%	13%	17%	13%	10%	15%	5%	3%	253	272	263
Lower Monumental Dam and Lake Herbert G. West	1%	2%	3%	9%	15%	16%	17%	14%	11%	8%	2%	1%	178	172	175
Ice Harbor Dam and Lake Sacajawea	3%	3%	4%	6%	12%	15%	21%	17%	9%	6%	3%	3%	208	213	211
Region C Total	4%	4%	6%	8%	11%	12%	14%	13%	8%	11%	5%	4%	3,066	2,969	3,017
McNary Dam and Lake Wallula	4%	5%	7%	9%	12%	12%	15%	10%	10%	6%	4%	4%	2,913	3,189	3,051
John Day Dam and Lake Umatilla	2%	3%	5%	9%	12%	14%	14%	11%	18%	6%	3%	2%	661	713	687
The Dalles Dam and Lake Celilo	4%	4%	6%	8%	13%	11%	14%	13%	13%	8%	4%	3%	1,052	1,101	1,076
Bonneville Dam and Lake Bonneville	5%	4%	6%	8%	9%	12%	14%	13%	10%	8%	5%	6%	1,699	1,483	1,591
Below Bonneville Dam	5%	5%	6%	8%	14%	14%	14%	9%	9%	7%	5%	3%	260	293	276
Region D Total	4%	4%	6%	8%	12%	12%	14%	12%	12%	7%	4%	4%	6,585	6,779	6,682
Total	4%	4%	6%	8%	12%	13%	16%	13%	10%	7%	4%	4%	13,168	13,246	13,207

452 Note: There is no visitation data for sites marked as ND. In general however, most of these reaches are outside areas that may experience effects based upon
453 H&H modeling results (see Table 3-222 for locations where a change in boat ramp accessibility change may occur).
454 This table displays available data from state and Federal agencies. Other agencies (e.g., counties, municipalities, etc.) are not included in this summary. There is
455 no standard definition of a “visit” across agencies and there is variation in how visitation data is collected. Specifically, some agencies have defined methods for
456 visitors who enter and exit a site multiple times during their visit and for visitors who only stop at the site for a few minutes (e.g., to use a restroom or ask for
457 directions). With the exception of the USFWS, a visit is generally defined as a single person entering a site for recreation regardless of the length of stay or
458 activities pursued. The USFWS estimates visitation based on unique activities pursued. For example, if a visitor takes a hike and goes hunting in a refuge, that
459 visitor would account for a hiking visit and a hunting visit. Visitation to National Forests and other USFS-managed lands is estimated for the entire unit.

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460 Estimates are not available for near-water sites, except for a subset of locations at Hungry Horse Reservoir, and are therefore excluded from this table.
 461 Visitation data for sites managed by Reclamation is collected by partner agencies.
 462 Totals and percentages presented in this table combine fiscal and calendar year data across agencies. Data from BLM, Corps, and USFWS reflects fiscal years
 463 while all other agencies provide data by calendar year.
 464 1/ Percentages are based on available monthly data from Federal and state agencies. Some agencies only report annual data.
 465 Source: MFWP 2017–2018 and email communication; NPS 2019a; other visitation data provided through personal communication with BLM, Corps, USFWS,
 466 USFS, IDPR, OPRD, and WSPRC.

467 **Table 3-257. Distribution of Recreation Use by Activity for Columbia River Basin Reservoirs and River Reaches**

Reservoir/River Reach	Fishing	Camping	Boating	Swimming	Picnicking	Hunting	Sightseeing	Other
Kootenai River between the U.S.-Canada border and Libby Dam and Lake Kooconusa	26%	1%	0%	5%	19%	0%	17%	31%
Flathead River above Flathead Lake and Hungry Horse Dam and Reservoir	ND	ND	ND	ND	ND	ND	ND	ND
Clark Fork River, Flathead River below Flathead Lake, and Flathead Lake	ND	ND	ND	ND	ND	ND	ND	ND
Pend Oreille River and Lake Pend Oreille	9%	11%	6%	12%	12%	1%	14%	35%
Region A Total	13%	8%	4%	10%	14%	1%	15%	34%
Grand Coulee Dam and Lake Roosevelt	33%	27%	20%	7%	1%	ND	ND	12%
Chief Joseph Dam and Rufus Woods Lake	34%	3%	4%	2%	7%	1%	36%	14%
Wells Dam and Lake Pateros	ND	ND	ND	ND	ND	ND	ND	ND
Rocky Reach Dam and Lake Entiat	ND	ND	ND	ND	ND	ND	ND	ND
Rock Island Dam and Pool	ND	ND	ND	ND	ND	ND	ND	ND
Wanapum Dam and Wanapum Lake	ND	ND	ND	ND	ND	ND	ND	ND
Priest Rapids Dam and Priest Rapids Lake	ND	ND	ND	ND	ND	ND	ND	ND
Hanford Reach below Priest Rapids Dam	ND	ND	ND	ND	ND	ND	ND	ND
Region B Total	33%	22%	17%	6%	2%	0%	7%	12%
Clearwater River and Dworshak Dam and Reservoir	36%	13%	6%	5%	5%	1%	17%	17%
Snake River below Hells Canyon Dam	ND	ND	ND	ND	ND	ND	ND	ND
Lower Granite Dam and Lower Granite Lake	13%	1%	7%	13%	9%	0%	11%	45%
Little Goose Dam and Lake Bryan	14%	4%	17%	15%	15%	1%	13%	20%
Lower Monumental Dam and Lake Herbert G. West	19%	15%	14%	7%	10%	1%	8%	26%
Ice Harbor Dam and Lake Sacajawea	27%	2%	13%	11%	14%	0%	13%	21%

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Reservoir/River Reach	Fishing	Camping	Boating	Swimming	Picnicking	Hunting	Sightseeing	Other
Region C Total	16%	3%	7%	12%	9%	1%	12%	40%
McNary Dam and Lake Wallula	7%	0%	15%	4%	13%	0%	18%	43%
John Day Dam and Lake Umatilla	27%	1%	21%	11%	17%	3%	10%	12%
The Dalles Dam and Lake Celilo	25%	0%	14%	9%	17%	3%	15%	16%
Bonneville Dam and Lake Bonneville	19%	0%	2%	2%	7%	0%	52%	17%
Below Bonneville Dam	ND	ND	ND	ND	ND	ND	ND	ND
Region D Total	32%	20%	16%	7%	4%	0%	8%	14%
Total	23%	11%	11%	9%	7%	0%	10%	28%

468 Note: Notes: There is no visitation data for sites marked as ND. In general however, most of these reaches are outside areas that may experience effects based
469 upon H&H modeling results (see Table 3-222 for locations where a change in boat ramp accessibility change may occur).
470 Data on recreational activities is not collected at all sites, even for those with visitation data reported in Table 3-256.
471 Source: Corps 2016d; Le and Strawn 2017
472

473 **3.11.3 Environmental Consequences**

474 The environmental consequences analysis for recreation evaluates how changes in reservoir,
475 river, and habitat conditions under MOs could affect visitation, recreational opportunities, and
476 the value of the recreation experience. This section provides an overview of the recreation
477 impact assessment methodology and presents the results of the assessment. A more detailed
478 description of the methodology, data, and results is provided in the Appendix M Recreation.

479 **3.11.3.1 Methodology**

480 The environmental consequences for recreation are evaluated across three categories: social
481 welfare effects (i.e., national economic development, or NED), regional economic effects (i.e.,
482 regional economic development, or RED), and other social effects. These categories provide an
483 organizing framework for evaluating direct and indirect effects, and for displaying potential
484 effects important to stakeholders and tribes, while ensuring effects are not double-counted.
485 The following sections provide a brief overview of the methodology used to evaluate the effects
486 by category.

487 River flows and reservoir elevations may change under the MOs as compared to the No Action
488 Alternative, which may cause changes in access to water-based recreation and may affect the
489 quality of recreational experiences. Decreased access to water-based recreation—which
490 includes fishing, boating, and swimming—would affect the amount of visitation to a site and
491 associated benefits to visitors and communities. Under MO3 water-based recreation on the
492 lower Snake River would change from reservoir recreation to riverine recreation, with different
493 water-based recreation conditions in the short term during dam breaching implementation,
494 versus the longer term.

495 The recreation analysis uses outputs from the H&H analysis, which simulates reservoir
496 operations and river conditions under each MO within a Monte Carlo framework (the H&H
497 modeling methods are described in Section 3.2). Reservoir elevation data from the H&H
498 analysis is compared to usable boat ramp elevations. Water surface elevations are compared
499 with minimum usable boat ramp elevations to assess the accessibility for water-based
500 recreators and estimate effects on recreational visitor days at reservoirs.³ A supplemental
501 analysis applying existing information is used to quantify potential changes in recreational
502 visitor day under for the dam breach scenario under the MOs.

503 While effects to water-based visitation from changes in boat ramp accessibility and/or lower
504 Snake River Dam breach are quantified, effects to river activities and non-water reservoir
505 activities are assessed qualitatively (e.g., changes in aesthetics/recreation setting due to
506 changes in flow and water surface elevations). Changes in river flows and stages during the
507 peak recreation season (May through September), where changes in flow of 10 percent or
508 more are assumed to have the potential to affect recreation. Smaller flow changes and changes

³ Maximum usable boat ramp elevations were also considered, but none of the H&H elevation data would extend above ramps under the MOs relative to the No Action Alternative.

509 in flows that would be outside of the peak recreation season are assumed to result in negligible
510 effects to recreation.

511 Potential effects to recreation-related resources and conditions, including recreational fishing,
512 water quality, and wildlife and habitat conditions, provide information about changes to the
513 quality of the recreation experience that may result from the MOs.

514 **SOCIAL WELFARE EFFECTS**

515 Social welfare effects consider both the change in the number of visitors (recreational visitor
516 days) that could occur, as well as the change in type of recreational activities and conditions
517 that could affect the quality of recreation experience. The analysis includes an assessment of
518 effects on a range of activities, including recreational fishing for anadromous and resident fish
519 species, boating, rafting/paddling opportunities, swimming, hunting, and wildlife viewing.
520 Effects to all recreationists (tribal and non-tribal) are considered in this analysis. Section 3.16,
521 Cultural Resources, and Section 3.17, Indian Trust Assets, Tribal Perspectives, and Tribal
522 Interests, provide additional information about ongoing effects as well unique effects of the
523 alternatives on tribal recreational activities, subsistence activities, and cultural practices.

524 The analysis considers the effects of the MOs on recreation over the 50-year period of analysis.
525 The 50-year period of analysis provide a long-term perspective, and enables the analysis to
526 distinguish between short-term and long-term impacts, recognizing that the effects to
527 recreation would likely be different, especially under MO3 in the short versus long term. The
528 evaluation considered the effects of hydrologic changes on annual visitation in the typical water
529 level year, as well as years with higher and lower water surface elevations. Although many
530 factors can contribute to visitation (price of gas, population growth, climate change, and
531 others), many of which are difficult to predict, the quantitative evaluation was focused on how
532 changes in boat ramp accessibility could affect water-based visitation, as well as how dam
533 breach of the lower Snake River projects (under MO3 only), could affect visitation. The results
534 are presented for the No Action and MOs as annual or annual equivalent effects over the 50-
535 year period of analysis.

536 **Recreational Visitation**

537 Decreased access to water-based recreation—which includes fishing, boating, and swimming—
538 would affect the amount of visitation to a site and associated benefits to visitors and
539 communities. The H&H analysis provides summary elevation and discharge hydrographs for
540 reservoirs and river reaches for each alternative. The hydrographs provide the 1 percent, 25
541 percent, 50 percent, 75 percent, and 99 percent exceedance water levels on each day of the
542 year. Results are also provided at the monthly level. The 50th percentile exceedance water level
543 is referred to as the “median water surface elevation” or the “water level in a typical year”
544 throughout this section. The recreation analysis uses the H&H hydrographs, in conjunction with
545 minimum usable boat ramp elevations, to assess changes in accessibility of boat ramps under
546 the MOs relative to the No Action Alternative. Visitation data for the reservoir sites is readily
547 available from Federal and state agencies, while visitation data for river reaches is limited.

548 Therefore, changes in boat ramp accessibility—and associated water-based recreational
549 visitation, such as boating and fishing—are estimated quantitatively at reservoirs only and are
550 described qualitatively for river reaches. The methodology for estimating changes in water-
551 based visitation at reservoirs is outlined below.

- 552 • **Estimate boat ramp accessibility under the No Action Alternative by reservoir.** Compare
553 minimum elevations required for boat ramps with modeled water surface elevations to
554 evaluate boat ramp accessibility by day under the No Action Alternative. The analysis
555 focuses on modeled daily water surface elevations associated with the 50th percentile
556 (typical year). These calculations are repeated for an average high-water-level year (25th
557 percentile) and an average low-water level-year (75th percentile) to understand variation in
558 the results. For each reservoir, the number of “accessible days,” or days with water surface
559 elevations above the minimum usable boat ramp elevations, is summed across boat ramps
560 by month.
- 561 • **Calculate the change in boat ramp accessibility under each MO.** Calculate the percentage
562 change in boat ramp accessibility by month for each MO relative to the No Action
563 Alternative based on the percentage change in total days that boat ramps would be
564 accessible in each month. For example, assume there are two boat ramps on a reservoir
565 that are accessible on every day within a month under the No Action Alternative. If one of
566 the two boat ramps is projected to be inaccessible for half of the month under an MO, then
567 the change in accessibility is assumed to be reduced by 25 percent for that reservoir for that
568 month.⁴
- 569 • **Estimate water-based visitation by reservoir under the No Action Alternative.** Monthly
570 water-based visitation in a typical year (i.e., 50th percentile) under the No Action Alternative
571 is estimated using reported reservoir visitation data from recent years and applying the
572 estimated proportion of water-based activities at each reservoir (fishing, boating, and
573 swimming).
- 574 • **Estimate changes in water-based visitation by reservoir associated with changes in boat
575 ramp accessibility.** The estimated changes in monthly boat ramp accessibility (Step 2) are
576 multiplied by the monthly estimates of water-based visitation (Step 3) to calculate monthly
577 changes in water-based visitation at each reservoir. Combining results across months yields
578 annual changes.

579 The methodology presented above includes a number of assumptions due to data limitations.
580 In particular, specific data about the behavior of recreationists when faced with varying river
581 and reservoir conditions in the Basin is not known with certainty. The assumptions used in this
582 analysis are conservative, i.e., they are more likely to overstate than understate effects of
583 changes to water-based visitation. In particular, quantified effects do not take into account the

⁴ The ramps provide 100 percent combined accessibility under the No Action Alternative but 75 percent accessibility under the MOs: 75 percent = 30/30 days for ramp 1 + 15/30 for ramp 2 = 45/60 across two ramps.

584 potential for spatial substitution or temporal substitution.⁵ Quantified effects do not take into
585 account potential actions that might be taken by resource managers to make a ramp accessible
586 under alternative water surface elevations (e.g., extending a ramp). The approach also uses
587 boat ramp accessibility as a representation of water-based recreation activity on the reservoirs.
588 That is, all water-based recreation is assumed to decrease when a boat ramp is inaccessible.
589 While some water-based activities, like shore fishing and swimming, might not vary in the same
590 manner as activities that rely directly on boat ramps (e.g., motorized boating), the assumption
591 was supported by conversations with reservoir recreation managers (Bureau of Recreation
592 Natural Resource Managers 2019).

593 Recreation visitation under MO3, particularly on the lower Snake River and at Lake Wallula,
594 would be impacted differently than what is described above. Lake Wallula (the reservoir
595 created by McNary Dam downstream of Ice Harbor Dam) would be affected by sediment
596 moving down from the lower Snake River during breaching activities. As discussed in the River
597 Mechanics Appendix (Appendix C), the effects of the 2 to 7 years of sedimentation would
598 primarily affect water-based recreation and boat ramp accessibility along the east and south
599 sides of the Columbia River in Lake Wallula below the mouth of the Snake River. This
600 information was used to assess the potential reductions in water-based visitation at certain
601 recreation areas and associated economic effects affected by sedimentation at Lake Wallula.
602 The process and timing for sediment movement through the system is described in detail in the
603 River Mechanics section (Section 3.3).

604 A supplemental analysis was conducted under MO3 for the four lower Snake River projects,
605 which would be uniquely affected by dam breaching. Recreation at the four lower Snake River
606 projects—Lower Granite Dam and Lake, Little Goose Dam/Lake Bryan, Lower Monumental
607 Dam/Lake Herbert G. West, and Ice Harbor Dam/Lake Sacajawea—would transition from
608 reservoir-based recreation to river-based recreation. Recognizing that land-based recreation
609 may return sooner than water-based recreation, the supplemental analysis quantifies potential
610 changes in water and land-based recreation at the four lower Snake River reservoirs under
611 MO3.

612 After and possibly during the breaching and infrastructure drawdown period, land-based
613 recreational activities at lower Snake River sites would likely reoccur as areas are reopened and
614 access is provided to curious sightseers, picnickers, hikers and others doing land-based
615 activities. Therefore, the recreation evaluation estimates both reductions in land- and water-
616 based visitation during dam breach, as well as a return of land based visitation shortly after
617 breaching as recreation areas become available. This information was used to assess the
618 potential changes in short term visitation and associated economic effects in the lower Snake
619 River compared to current visitation under the No Action Alternative.

⁵ That is, if a particular boat ramp is made temporarily inaccessible by changes in reservoir elevations, a recreationist might use a different ramp or pursue a shore-based activity on a given trip occasion. The current methodology assumes that recreationists will forego that particular visit. Second, quantified effects do not take into account the potential for temporal substitution. That is, a recreationist may take a trip earlier or later in time to make up for a lost trip on another occasion due to an inaccessible boat ramp.

620 Potential increases in visitation associated with the new river recreational opportunities in the
621 long-term (e.g., fishing, rafting, paddling, as well as land-based activities) are evaluated through
622 a review of previous studies and similar river reaches. However, the issue of recreation access is
623 also discussed under MO3. Without the federal reservoirs the Corps will not have a role in
624 providing recreation facilities, therefore in order to reestablish recreation opportunities and
625 water access in the region, there would likely be a cost impact to a government agency.

626 The potential for recreational fishing in the long term and the quality of the recreational
627 experience under MO3 uses information provided in Section 3.5, *Aquatic Habitat, Aquatic*
628 *Invertebrates, and Fish*, which describes the increases in the abundance of anadromous
629 recreational fishing species due to dam breaching under MO3. The evaluation also describes
630 the possible limitations associated with recreational fishing activities, including the elimination
631 of federally funded hatchery production operations associated with the four lower Snake River
632 projects and fishing regulations to protect the ESA-listed species. However, the value
633 (consumer surplus) for recreational fishing may also increase due to increased abundance and
634 diversity of wild fish, which is described qualitatively.

635 Across the MOs, a change in recreational visitation due to changes in boat ramp accessibility is
636 anticipated at nine CRS reservoirs (Table 3-258). This is based on the H&H modeling results as
637 well as information related to the lower Snake River dam breaches under MO3. Additional non-
638 CRS reservoirs in the system were also assessed, but no changes in boat ramp accessibility
639 would be anticipated because changes in water surface elevations would be negligible.

640 **Table 3-258. Columbia River System Operations Reservoirs Where a Change in Boat Ramp**
641 **Accessibility Under Each Alternative is Anticipated**

CRSO Region	Reservoir	NAA	MO1	MO2	MO3	MO4
Region A	Lake Koocanusa		X	X	X	X
Region A	Hungry Horse Reservoir		X	X	X	X
Region A	Lake Pend Oreille					**
Region B	Lake Roosevelt		X	X		X
Region B	Lake Rufus Woods					
Region C	Dworshak Reservoir		X	X		
Region C	Lower Granite Lake				X*	
Region C	Lake Bryan				X*	
Region C	Lake Herbert G. West				X*	
Region C	Lake Sacajawea				X*	
Region D	Lake Wallula				X*	
Region D	Lake Umatilla					
Region D	Lake Celilo					
Region D	Lake Bonneville					

642 Note: The sites marked with an "X" were identified as exhibiting changes in site accessibility using H&H modeling
643 results. The sites with an asterisk (*) were analyzed separately using information related to the lower Snake River
644 dam breaches under MO3. "***" marks potential effects at Lake Pend Oreille in low water years only.

645 **Consumer Surplus Value of Recreational Visitation**

646 Social welfare effects are evaluated by estimating the change in economic value (i.e., consumer
647 surplus) resulting from estimated changes in recreational visitation at reservoirs. The
648 procedures described in the Economic and Environmental Principles and Guidelines for Water
649 and Related Land Resources Implementation Studies (Water Resources Council 1983)
650 (Principals and Guidelines) outline three generally accepted methods for measuring
651 recreational benefits: the unit day value (UDV), the travel cost method, and contingent
652 valuation. Although a current site specific travel cost or contingent value approach would be a
653 preferred method, a more detailed analysis at this geographic scale was not possible under the
654 timeline of the study. Therefore the recreation analysis uses another standard Corps approach
655 to evaluate recreation consumer surplus benefit, the UDV approach (Corps 2019; Water
656 Resources Council 1983). The UDV method relies on expert and informed opinion to assign
657 relative values to recreational visits based on the quality of recreational opportunities
658 supported by individual recreation areas. The UDV approach provides a consistent approach
659 across all sites in the evaluation (Chang 2019).⁶

660 The social welfare analysis is done in two steps. First, recreational visits are converted to
661 recreational visitor days to account for the fact that overnight trips are longer than 1 day (refer
662 to Recreation Appendix M, Section 2.2 for additional details on recreation visitor day
663 calculation). Once all visits have been standardized to days, the UDV approach can be applied.
664 The most recent UDV's (FY 2018) were used for this analysis and updated to 2019 dollars using
665 the Consumer Price Index (CPI; Bureau of Labor Statistics 2019). The UDV estimates range from
666 \$7.95 to \$9.87 per day, depending on the project. The UDV estimates were obtained from the
667 Corps Recreation Budget Evaluation System (RecBest) (Chang 2019). Additional details on the
668 calculation of UDV by reservoir are provided in Appendix M.

669 **Quality of Recreational Experience**

670 In addition to factors that may affect site visitation through changes to accessibility, other
671 factors under the MOs may also affect the quality of recreational experiences. These include
672 effects associated with changes in recreational fishing conditions, water quality conditions, and
673 hunting and wildlife viewing conditions. While changes in the quality of recreational
674 experiences may also influence visitation, the effects are more difficult to quantify given the
675 data available for this analysis. For this reason, effects of changes to site conditions that would
676 affect the quality of recreational experiences are considered qualitatively under the MOs.

⁶ In general, the UDV method uses estimates of economic value that are notably lower than those found in other available sources (e.g., Recreation Use Valuation Database [RUVD], Benefits Transfer Toolkit). The RUVD provides consumer surplus values from hundreds of studies for various recreational activities and locations. Consumer surplus values from the RUVD range from a median of \$24 to \$68 per day depending on the recreational activity in the Pacific Northwest.

677 **Fishing Conditions**

678 The analysis described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, provides
679 information on anticipated changes in population characteristics for a range of fish species
680 across different reaches (i.e., reservoirs and sections of river) for each MO. The information
681 includes anadromous species—including several salmonids, Pacific lamprey, sturgeon,
682 American shad, and eulachon—and resident species, including trout, smallmouth bass, walleye,
683 burbot, channel catfish, and northern pikeminnow. Many of these species are targeted by
684 recreational anglers throughout the Basin. Reservoirs provide substantial warm-water fishing
685 opportunities for resident species, while anadromous species are often targeted in cold-water
686 river fisheries.

687 The MOs that improve fish survival and abundance would generally result in beneficial effects
688 for recreational fishing, while MOs that reduce fish survival and abundance would adversely
689 affect recreational fishing.⁷ In particular, the presence of additional fish may improve the
690 quality of existing recreational fishing trips (e.g., through increased catch rates), resulting in
691 additional value (consumer surplus) for anglers (i.e., a higher UDV). Additional fish may also
692 generate additional trips as more anglers could be supported (Melstrom et al. 2015; Poe et al.
693 2013). Different types of recreational fishing opportunities (e.g., reservoir versus river) often
694 necessitate specialized gear and equipment for targeting specific sport fish species as well as
695 different fishing techniques (e.g., fly fishing, boat fishing, shore fishing). It is noted that a
696 change in recreational fishing opportunities from reservoir to river fishing would have impacts
697 on individuals seeking specific opportunities even if overall recreational use data percentages
698 remain stable for fishing activities within a region. Non-fishing recreational activities would
699 likely not be affected by changes in fish abundance or distribution, though changes in the levels
700 of angler visitation could affect crowding at sites. The effects to fishing visitation and
701 experience and associated recreation consumer surplus are evaluated qualitatively based on
702 the results of the fish analysis.

703 **Water Quality Conditions**

704 The water quality analysis (Section 3.4) summarizes the effects of the MOs on a range of water
705 quality metrics in affected river reaches and reservoirs.⁸ Water quality metrics that have the
706 potential to affect the quality and quantity of recreational visits include the following:

- 707 • Water temperature, which has the potential to affect the attractiveness of particular sites
708 for in-water activities such as swimming.
- 709 • Total suspended solids/turbidity and light attenuation, which affect water clarity. Changes
710 in aesthetics from enhanced or diminished water clarity can affect a range of water- and
711 land-based recreational activities.

⁷ The pikeminnow is a potential threat to salmon populations, so increases in that species may adversely affect salmon and, by extension, anglers targeting salmon.

⁸ Changes in water quality that affect fish survival and abundance are reflected in the outputs from the fish analysis.

- 712 • Nutrient loading (nitrogen and phosphorous); organic compounds/metals in water,
713 sediment, and fish tissue; chlorophyll a; and coliforms and other microbes, which affect the
714 likelihood of algal blooms and are reflective of pollution levels. Changes in the occurrence
715 or frequency of algal blooms as well as pollutant levels have the potential to affect the
716 attractiveness of particular sites for recreation (e.g., adverse changes to aesthetics/setting)
717 and lead to health and safety concerns (Graham, Dubrovsky, and Eberts 2017). Metals in
718 fish tissue that lead to the issuance or strengthening of fish consumption advisories (FCAs)
719 would have an adverse effect on recreational anglers in particular.

720 ***Hunting and Wildlife Viewing Conditions***

721 The vegetation, wildlife, floodplains, and wetlands analyses (Section 3.6) provide information
722 on anticipated changes in habitat conditions for wildlife, including ESA-listed mammals, birds,
723 amphibians and plants. Changes in habitat conditions for species valued by hunters, wildlife
724 viewers, and other outdoor recreationists have the potential to affect the quality of the
725 recreation experience for these visitors and potentially the number of trips taken for these
726 activities. As noted above, Section 3.16, *Cultural Resources*, and Section 3.17, *Indian Trust*
727 *Assets, Tribal Perspectives, and Tribal Interests*, provide additional information about ongoing
728 effects as well as the unique effects of the MOs on tribal recreational activities, subsistence
729 activities, and cultural practices.

730 **REGIONAL ECONOMIC EFFECTS**

731 Regional economic effects are measures of changes in economic activity as a result of changes
732 in expenditures (also known as visitor spending) associated with recreational visitation. The
733 approach to assess the regional economic effects is briefly described in this section. First,
734 quantified changes in visitation resulting from changes in water surface elevations and boat
735 ramp accessibility (results from the social welfare effects evaluation) are multiplied by per-day
736 visitor spending estimates for recreation in the region.

737 The change in non-local visitation was estimated based on data on visitation patterns at
738 affected sites. The focus of the regional economic effects evaluation was on non-local visitors
739 because, while local visitors are likely to continue to spend money in the affected area even if
740 they forgo particular recreation trips, non-local visitors may divert spending to other areas if
741 particular trips are not taken due to access issues. A majority of visitors in the study area are
742 considered to be non-local (agencies define local by the distance travelled to sites, which is
743 generally 30 or 60 miles, depending on agency). The percentage of visitors who are non-local
744 are presented by reservoir/river reach, CRS region, and in total in Appendix M.

745 Second, estimates of non-local visitor spending are used to estimate the broader effects on
746 regional economic activity in terms of jobs, income, and sales using the input-output model,
747 IMPLAN. IMPLAN is a widely used industry-standard input-output data and software system
748 that is used by many Federal and state agencies to estimate regional economic effects. The
749 underlying data for IMPLAN is derived from multiple sources, including the Bureau of Economic

750 Analysis, the Bureau of Labor Statistics, and the U.S. Census Bureau. Any potential effects to
751 regional economies associated with changes in recreation quality are discussed qualitatively.

752 Regional economic effects are presented by CRS region and in total for the Basin. The study
753 area for each region includes multi-county areas. IMPLAN data for these multi-county areas was
754 used for this analysis; Table 3-259 lists the counties in each CRS region. A county was assigned
755 to a CRS region if the majority of the county’s area lies within the region.

756 **Table 3-259. Counties by Columbia River System Region**

Region A	Region B	Region C	Region D
Benewah (ID)	Adams (WA)	Adams (ID)	Benton (WA)
Bonner (ID)	Chelan (WA)	Asotin (WA)	Clark (WA)
Boundary (ID)	Douglas (WA)	Clearwater (ID)	Clatsop (OR)
Deer Lodge (MT)	Ferry (WA)	Columbia (WA)	Columbia (OR)
Flathead (MT)	Grant (WA)	Custer (ID)	Cowlitz (WA)
Granite (MT)	Lincoln (WA)	Franklin (WA)	Crook (OR)
Kootenai (ID)	Okanogan (WA)	Garfield (WA)	Deschutes (OR)
Lake (MT)	Stevens (WA)	Idaho (ID)	Gilliam (OR)
Lincoln (MT)		Latah (ID)	Grant (OR)
Mineral (MT)		Lemhi (ID)	Hood River (OR)
Missoula (MT)		Lewis (ID)	Jefferson (OR)
Pend Oreille (WA)		Nez Perce (ID)	Kittitas (WA)
Powell (MT)		Union (OR)	Klickitat (WA)
Ravalli (MT)		Valley (ID)	Lewis (WA)
Sanders (MT)		Walla Walla (WA)	Morrow (OR)
Shoshone (ID)		Wallowa (OR)	Multnomah (OR)
Silver Bow (MT)		Whitman (WA)	Sherman (OR)
Spokane (WA)			Skamania (WA)
			Umatilla (OR)
			Wahkiakum (WA)
			Wasco (OR)
			Washington (OR)
			Wheeler (OR)
			Yakima (WA)

757 **OTHER SOCIAL EFFECTS**

758 Other social effects include additional effects associated with changes in recreation conditions
759 and activities that are not already captured in the social welfare and regional economic effects
760 analyses. Given this, other social effects may include changes that affect community well-being,
761 identity, or cohesion. Social effects could occur if there is a substantial change in recreation
762 opportunities or displacement of recreation that result in a change in the number of tourism
763 and recreation businesses in a particular community, affecting community well-being, stability,
764 community cohesion, or all of the above. These effects are evaluated qualitatively based on the

765 results of the recreation social welfare and regional economic effects evaluations. As noted
766 above, Section 3.16, *Cultural Resources*, and Section 3.17, *Indian Trust Assets, Tribal*
767 *Perspectives, and Tribal Interests*, provide additional information about ongoing effects as well
768 unique effects of MOs on tribal recreational activities and cultural practices.

769 **3.11.3.2 No Action Alternative**

770 Visitation data for 2017 and 2018 is used to estimate annual visitation for the period of analysis
771 under the No Action Alternative, which is assumed to represent a typical year of visitation.
772 Using 2017–2018 visitation in future years under the No Action Alternative is supported by
773 recent visitation trends at Lake Roosevelt and communications with recreation managers.⁹
774 Visitation estimates are used to estimate recreational consumer surplus values and regional
775 economic effects, which are presented in this section.

776 The No Action Alternative would continue to provide social welfare benefits, regional economic
777 benefits, and other social benefits associated with considerable recreational opportunities in
778 the region. Continued operation of the system would provide benefits to community well-
779 being, cohesion, and identity similar to current conditions across the study area.

780 **REGION A**

781 As stated in the Affected Environment section, Region A contains at least 124 recreation access
782 points on or near the mainstem rivers and reservoirs that are managed by Federal and state
783 agencies. The area includes portions of the Colville National Forest, Idaho Panhandle National
784 Forests, Kootenai National Forest, Lolo National Forest, Flathead National Forest, and
785 Beaverhead-Deerlodge National Forest. This region also includes lands of four Indian Tribes: the
786 Kootenai Tribe, CSKT (Flathead Reservation), Kalispel Tribe, and Coeur D’Alene Tribe. Average
787 visitation to sites within a mile of the river in Region A was estimated to be 1.5 million in 2017–
788 2018. This analysis assumes that visitation would continue under the No Action Alternative.

789 A wide range of land- and water-based recreation would occur under the No Action Alternative,
790 with most visitation occurring at Lake Koocanusa, Hungry Horse Reservoir, and Albeni Falls/Lake
791 Pend Oreille. Regional visitation would generate annual welfare benefits of \$15 million. Visitor
792 expenditures associated with non-local visitors of at least \$67 million annually would support
793 860 annual jobs, \$30 million in regional labor income, and \$88 million in regional sales annually.
794 For comparison, total economic activity in Region A supports 644,600 jobs, \$30.2 billion in labor
795 income, and \$88.1 billion in sales annually (IMPLAN 2017).

⁹ While data is not available prior to 2017 for most sites, visitation at Lake Roosevelt—where NPS data is available back to 1941—has been relatively flat over recent decades despite growth in population and changes in other factors. Based on this evidence, in concert with input from recreation managers at the Corps and uncertainty about future changes to other factors that affect recreation, no adjustments were made to the average visitation numbers for future years.

796 **REGION B**

797 Region B encompasses at least 89 recreation access points on or near water that are managed
798 by Federal and State agencies. Table 3-253 summarizes land ownership for protected lands
799 located within 1 mile of the Columbia River in Region B, many of which are accessible to
800 recreationists. This area includes lands of the Spokane Tribe of Indians and the Confederated
801 Tribes of the Colville Reservation. The NPS manages approximately one-quarter of protected
802 areas within 1 mile of the mainstem Columbia River, primarily associated with Lake Roosevelt
803 National Recreation Area. The Hanford Reach National Historic Monument is also in this region.
804 Average visitation to sites within a mile of the river in Region B was estimated to be 2 million in
805 2017–2018. This analysis assumes that visitation would continue under the No Action
806 Alternative.

807 A wide range of land- and water-based recreation would occur under the No Action Alternative,
808 with most visitation occurring at Lake Roosevelt, and to a lesser extent at Rufus Woods Lake.
809 Regional visitation would generate annual welfare benefits of \$25 million. Visitor expenditures
810 associated with non-local visitation of at least \$77 million annually would support
811 approximately 840 annual jobs, \$26 million in regional labor income, and \$88 million in regional
812 sales annually. For comparison, total economic activity in Region B supports approximately
813 180,000 jobs, \$8.6 billion in labor income, and \$25.6 billion in sales annually (IMPLAN 2017).

814 **REGION C**

815 Region C encompasses at least 129 recreation access points on or near water that are managed
816 by Federal and state agencies and private (for profit) entities. Table 3-254 summarizes land
817 ownership for protected lands located within 1 mile of the Snake and Clearwater Rivers in
818 Region C, many of which are accessible to recreationists. The USFS manages more than half (58
819 percent) of protected lands in this area, which includes portions of a number of national
820 forests. In addition to Wallowa-Whitman National Forest, the area includes portions of Hells
821 Canyon Recreation Area and Wilderness Area, the Nez-Perce Clearwater National Forest, and
822 Payette National Forest, among others. The Corps manages the lakes behind all of the Snake
823 River dams in this region. Over 73,000 acres of Nez Perce Tribe lands are also captured in the
824 areas within 1 mile of the Snake River. Average visitation to sites within a mile of the river in
825 Region C was estimated to be approximately 3 million in 2017–2018. This analysis assumes that
826 visitation would continue under the No Action Alternative.

827 A wide range of land- and water-based recreation would occur, with most visitation occurring
828 at the four lower Snake River and Dworshak Reservoirs. About 63 percent of regional visitation
829 occurs at Lower Granite Lake near Lewiston, Idaho. Regional visitation totaling 3.0 million
830 annual visits would generate annual welfare benefits of \$30 million. Visitor expenditures
831 associated with non-local visitation of approximately \$124 million annually would support 1,490
832 annual jobs, \$47 million in regional income, and \$176 million in regional sales annually. For
833 comparison, all economic activity in Region C supports 216,800 jobs, \$10.3 billion in labor
834 income, and \$31.4 billion in sales annually.

835 **REGION D**

836 The region encompasses at least 215 access points on or near water that are managed by
837 Federal and state agencies. Table 3-255 summarizes land ownership for protected lands located
838 within 1 mile of the Columbia River in Region D, many of which are accessible to recreationists.
839 The USFS manages the largest share of protected lands in this region, with USFWS and the
840 Corps also managing a substantial share of lands. In addition to the Columbia River Gorge
841 National Scenic Area, a portion of the Lewis and Clark National Historic Trail is in this region.
842 Average visitation to sites within a mile of the river in Region D was estimated to be 6.7 million
843 in 2017–2018. This analysis assumes that visitation would continue under the No Action
844 Alternative.

845 A wide range of land- and water-based recreation would occur at reservoirs on the lower
846 Columbia River and along the river below Bonneville Dam. About 86 percent of regional
847 visitation occurs at Lake Wallula, Lake Celilio, and Lake Bonneville. Regional visitation totaling
848 6.7 million annual visits would generate annual welfare benefits of \$63 million. Visitor
849 expenditures associated with non-local visitation of approximately \$231 million annually would
850 support 2,910 jobs, \$127 million in regional income, and \$394 million in regional sales. For
851 context, all economic activity in Region D supports approximately 1.9 million jobs, \$113.9 billion
852 in labor income, and \$330.4 billion in sales annually (IMPLAN 2017).

853 **SUMMARY OF EFFECTS**

854 Table 3-260 summarizes recreation conditions under the No Action Alternative for a typical year.
855 Across the Basin, total recreational visitation at sites within 1 mile of the mainstem rivers,
856 including water- and land-based use at reservoirs and river reaches, is anticipated to be
857 approximately 13 million visits annually.¹⁰ This recreational visitation is anticipated to support
858 over \$133 million in annual consumer surplus value (social welfare), primarily at CRS reservoirs.¹¹

859 Visitor expenditures by non-local visitors are anticipated to be \$499 million across the study
860 area (as described in Section 3.11.3.2) annually under the No Action Alternative, with most of
861 the expenditures occurring in Regions C and D. Regional economic effects associated with these
862 expenditures on recreation in the Basin are anticipated to result in 6,480 annual jobs, \$265
863 million in labor income, and \$843 million in sales across the recreation study area annually. To
864 put these numbers in context, across the Basin, all economic activity supports 2.9 million jobs,
865 \$163.0 billion in labor income, and \$475.5 billion in sales annually. Recreational opportunities
866 under the No Action Alternative would continue to support social well-being and quality of life,
867 especially in the communities surrounding and adjacent to recreational sites. Sites in rural areas
868 likely have a larger effect on local economic activity and community identity because there is
869 less economic diversity and relatively higher reliance on local recreation-related businesses,
870 recreational amenities, and features.

¹⁰ Because regional visitation data from Federal and state agencies is more comprehensively collected for reservoirs and are limited for sections of river between reservoirs (see Section 3.11.2.2), total estimated visitation primarily reflects reservoir-based recreation.

¹¹ More information about boat ramp accessibility under the No Action Alternative, including boat ramp accessibility by month is provided in Appendix M.

871 **Table 3-260. Summary of Average Annual Effects of Recreation Under the No Action Alternative (2019 Dollars)**

Region	Social Welfare Effects	Regional Economic Effects	Other Social Effects
Region A	A wide range of land- and water-based recreation would occur, with most visitation occurring at Lake Kocanusa, Hungry Horse Reservoir, and Albeni Falls/Lake Pend Oreille. Regional visitation totaling 1.5 million visits would generate annual welfare benefits of \$15 million. Current conditions for fish, wildlife, and water quality would continue to support recreational experiences in the river and reservoirs.	Non-local visitor expenditures of approximately \$67 million annually would support 860 annual jobs, \$30 million in regional labor income, and \$88 million in regional sales annually.	The No Action Alternative would continue to provide other social effects associated with considerable recreational opportunities in the region. Continued operation of the system would provide benefits to community well-being, cohesion, and identity similar to current conditions across the study area. However, long-term adverse effects of system operations on area tribes would continue.
Region B	A wide range of land- and water-based recreation would occur, with most visitation occurring at Lake Roosevelt, and to a lesser extent at Lake Rufus Woods. Regional visitation totaling 2.0 million annual visits would generate annual welfare benefits of \$25 million.	Non-local visitor expenditures of approximately \$77 million annually would support 840 annual jobs, \$26 million in regional labor income, and \$88 million in regional sales annually.	
Region C	A wide range of land- and water-based recreation would occur, with most visitation occurring at the four lower Snake River and Dworshak Reservoirs. About 63 percent of regional visitation occurs at Lower Granite Lake near Lewiston, ID. Regional visitation totaling 3.0 million annual visits would generate annual welfare benefits of \$30 million.	Non-local visitor expenditures of approximately \$124 million annually would support 1,490 annual jobs, \$47 million in regional income, and \$176 million in regional sales annually.	
Region D	A wide range of land- and water-based recreation would occur at reservoirs on the lower Columbia River and along the river below Bonneville Dam. About 86 percent of regional visitation occurs at Lake Wallula, Lake Celilo, and Lake Bonneville. Regional visitation totaling 6.7 million annual visits would generate annual welfare benefits of \$63 million.	Non-local visitor expenditures of approximately \$231 million annually would support 2,910 jobs, \$127 million in regional income, and \$394 million in regional sales.	
Total	A wide range of land- and water-based recreation within 1 mile of mainstem rivers would result in 13 million annual visits to the region. This visitation would generate annual welfare benefits of \$133 million.	Non-local visitor expenditures of approximately \$499 million annually would support 6,480 jobs, \$265 million in income, and \$843 million in regional sales annually.	

872

873 **3.11.3.3 Multiple Objective Alternative 1**

874 MO1 includes operational changes to Libby, Hungry Horse, Grand Coulee, Dworshak, and John
875 Day Dams. The anticipated changes in water surface elevations at Lake Kooconusa, Hungry
876 Horse Reservoir, Lake Roosevelt, and Dworshak Reservoir could affect boat ramp accessibility
877 for some periods of time during the year, and hence, access and visitation for some water-
878 based visitors. Water quality and fishing conditions within reservoirs, as well as in some stream
879 reaches below reservoirs, may also be affected under MO1. The effects of MO1 on recreation
880 due to changes in the above resources are described for each region.

881 **SOCIAL WELFARE EFFECTS**

882 The focus of effects on water-based visitation in this section are described as annual effects
883 that would occur after implementation of MO1. Over time, visitors may adjust their behavior to
884 adapt to changes in accessibility and site quality, such as utilizing different sites on the system.
885 These long-term adaptations could reduce effects that are reported in this section.

886 **Region A – Libby, Hungry Horse, and Albeni Falls Dams**

887 Under MO1, measures impacting recreation in Region A include a *Sliding Scale at Libby and*
888 *Hungry Horse*, a single *December Libby Target Elevation*, and *Hungry Horse Additional Water*
889 *Supply*. Because no structural measures are planned for Region A under MO1, the effect on
890 recreation is directly tied to changes in water elevations and flows related to operational
891 changes. These changes would be similar in the short term and longer term, over the 50-year
892 period of analysis. However, as noted above, recreationists may adjust their behavior over
893 time, which would reduce effects on visitation.

894 ***Water-based Recreational Visitation***

895 Anticipated changes in water surface elevations under MO1 would affect boat ramp
896 accessibility relative to the No Action Alternative at Lake Kooconusa (Libby Dam) and Hungry
897 Horse Reservoir in Region A for some periods of time in a typical year. This change in
898 accessibility would likely affect visitation to these sites. Changes in water levels at other
899 reservoirs in the region would not affect accessibility and visitation. Due to changes in project
900 outflows, recreational activities occurring in river reaches downstream of Libby Dam and
901 Hungry Horse Dam could cause beneficial effects or adverse localized effects, or both,
902 depending upon the river-based recreation activity.

903 At Lake Kooconusa, median water surface elevations would be higher for the majority of the
904 year under MO1 relative to the No Action Alternative but would be lower by 2 to 3 feet on
905 average March through May. The surface water elevations in March and April under MO1
906 would fall below the minimum usable elevations at some boat ramps, causing a decrease in
907 boat ramp accessibility at the reservoir relative to the No Action Alternative. No accessibility
908 effects are expected in May. Conversely, there would be increases in boat ramp accessibility in
909 June and December due to higher median water surface elevations relative to the No Action

910 Alternative (there is very little recreation in January). Due to minor changes in boat ramp
911 accessibility (both decreases and increases), water-based recreational visitation is estimated to
912 decrease slightly (by less than 1 percent, approximately 234 visits) annually under MO1 relative
913 to the No Action Alternative at Lake Koochanusa in a typical water year. In a high-water year (i.e.,
914 25th percentile) water-based visitation would increase slightly (less than 0.2 percent) relative to
915 the No Action Alternative high-water year. In a low-water year (i.e., 75th percentile), water-
916 based visitation would increase slightly (less than 0.5 percent) relative to the No Action
917 Alternative low-water year. In these years, any losses in visitation in some months would be
918 offset by increases in visitation during other months.

919 At Hungry Horse Reservoir, median water surface elevations would be lower for the majority of
920 the year under MO1 relative to the No Action Alternative, with declines of several feet on some
921 days (see Appendix B, *Hydrology and Hydraulics*, for detail). The lower water surface elevations
922 would result in decreased boat ramp accessibility in every month except July, August, and
923 September. Because recreational visitation typically occurs between May and September at
924 Hungry Horse, changes in boat ramp accessibility would lead to changes in water-based
925 visitation in May and June only. Negligible to minor effects on recreational visitation are
926 expected; water-based recreational visitation at Hungry Horse would decrease by
927 approximately 1 percent (26 visits) annually in a typical year. Similar results would be expected
928 in low- and high-water years. Changes in social welfare value associated with visitation changes
929 at both Lake Koochanusa and Hungry Horse Reservoir would be negligible, about \$3,000 in a
930 typical year.

931 In addition to changes in reservoir elevations, river flows and stages in the region would change
932 relative to the No Action Alternative. Increased occurrence of higher flows may create localized
933 water turbidity and adversely affect nearby in-river recreational fishing activities. However,
934 rafting and paddling activities may be beneficially affected. Both beneficial and adverse effects
935 under MO1 are anticipated to be minor in river areas. The largest change in monthly median
936 outflow from Libby Dam during peak recreation season is a decrease of 20 percent in May
937 relative to the No Action Alternative. At Bonners Ferry, further down the Kootenai River, flows
938 and stages would increase during several months, though the biggest changes in median
939 conditions occur in winter months when visitation is low. Outflows from Hungry Horse Dam in
940 the Flathead River would increase in the summer months, with the biggest changes of 21
941 percent in August and September. Smaller changes in river flows and stages (less than 10
942 percent) would occur elsewhere during peak recreation season in Region A under MO1.

943 ***Quality of Recreational Experience***

944 Changes in the quality of recreational experience are anticipated to be negligible in Region A
945 under MO1. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, there
946 would be some increased resident fish entrainment and reduced food supply at and
947 downstream of Hungry Horse Dam in Region A, as well as a minor decrease in useable summer
948 habitat in the mainstem Flathead River above Flathead Lake. However, the majority of fishing
949 activity, which occurs in Flathead Lake, would be minimally affected. None of these changes

950 would likely be noticeable to recreational anglers. Changes at Pend Oreille and in the Kootenai
951 River would be minimal. No changes to recreation are anticipated on the Clark Fork River.

952 Lake Koocanusa (Libby Dam) would undergo changes in water surface elevations that could
953 have a minor effect on water temperatures under MO1, but these changes would be minor and
954 unlikely to impact the recreational use of the reservoir. It is possible that the operational
955 changes proposed for MO1 may impact the nutrient levels in Lake Koocanusa, which could
956 result in increased nuisance aquatic plant and algae growth during the growing season. These
957 operational changes, however, are minor and only occur during more extreme water years
958 (high/low water years) which likely would reduce the potential effects to recreational areas.
959 Effects to recreation associated with changes in wildlife abundance are not anticipated in
960 Region A under MO1.

961 **Region B – Grand Coulee and Chief Joseph Dams**

962 Grand Coulee operational measures include the *Lake Roosevelt Additional Water Supply*
963 measure and various flood risk management operations such as decreasing the *Planned Draft*
964 *Rate at Grand Coulee*, constraining *Grand Coulee Maintenance Operations*, and adding *Winter*
965 *System FRM Space* to protect against rain-induced flooding. Chief Joseph operational measures
966 include increased diversions for water supply (i.e., the *Chief Joseph Dam Project Additional*
967 *Water Supply* measure). Because no additional measures are planned for Region B under MO1,
968 the effect on recreation is directly tied to changes in water surface elevations and flows related
969 to operational changes. These changes would be similar over the 50-year period of analysis.
970 However, as noted above, recreationists may adjust their behavior over time, which would
971 reduce effects on visitation.

972 ***Water-based Recreational Visitation***

973 Anticipated changes in water surface elevations under MO1 would affect boat ramp
974 accessibility at Lake Roosevelt in Region B relative to the No Action Alternative. Other reservoirs
975 in the region would not be affected. Relative to the No Action Alternative, anticipated water
976 surface elevations would be lower for the majority of the year, with the biggest median
977 decreases occurring in winter months (where reservoir levels would drop 2 to 6 feet).
978 Decreases during the peak recreation season months would be less than 1 foot on average in
979 Region B under MO1. Decreases in boat ramp accessibility relative to the No Action Alternative
980 are anticipated for most months. Decreases in accessibility are 2 percent or less, except in
981 February when a 12 percent decrease in accessibility would occur. However, visitation is low
982 during winter months.

983 Water-based visitation would decrease by less than 1 percent (approximately 6,000 visits)
984 annually in a typical year. In a high-water year (i.e., 25th percentile) visitation would decrease
985 by 3 percent when compared to a high-water year under the No Action Alternative. In a low-
986 water year (i.e., 75th percentile), visitation would decrease by about 1.5 percent when
987 compared to a low-water year under the No Action Alternative. Changes in social welfare value

988 associated with the visitation change in a typical year would be about \$91,000. A negligible to
989 minor effect on water-based reservoir recreation is expected.

990 Changes in river flows and stages between dams would be minor (less than 10 percent) relative
991 to the No Action Alternative and therefore would not be expected to affect river recreation.

992 **Quality of Recreational Experience**

993 Changes in the quality of recreational experience are anticipated to be negligible in Region B
994 under MO1. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*,
995 changes in instream survival of modeled anadromous fish species would be similar under MO1
996 to the No Action Alternative in Region B. Increased entrainment risk for some resident species
997 and water elevation changes at the reservoir could increase stranding of kokanee and burbot
998 eggs, which could adversely affect the destination fishery at Lake Roosevelt. These seem to be
999 minor changes that would not likely be noticeable to most recreational anglers. In Region B,
1000 Lake Roosevelt would experience improved water clarity from the slower *Planned Draft Rate at*
1001 *Grand Coulee* under MO1, including reduced levels of total suspended solids and turbidity.
1002 While current water clarity is generally good at Lake Roosevelt, the improved water clarity
1003 could marginally improve the experience for picnickers, swimmers, boaters, and campers.

1004 As described in Section 3.6, *Vegetation, Wildlife, Floodplains, and Wetlands*, under MO1 in
1005 Region B, decreased water surface elevations in the winter in Lake Roosevelt could have minor
1006 effects on predator populations, as well as ungulate populations in the Grand Coulee Dam area.
1007 Increasing the barren zone during the winter under lower water surface elevations could
1008 displace big game populations and provide increased area for mountain lion to hunt and kill
1009 prey animals around Lake Roosevelt. There could be some negligible to minor changes in the
1010 recreational experiences for hunters and wildlife viewers associated with these changes.

1011 **Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams**

1012 Under MO1, operational measures impacting recreation in Region C include the *Increased*
1013 *Forebay Range Flexibility* and *Modified Dworshak Summer Draft* measures. These changes
1014 would be similar over the 50-year period of analysis. However, as noted above, recreationists
1015 may adjust their behavior over time, which would reduce effects on visitation.

1016 Structural measures impacting recreation in Region C include the *Additional Powerhouse*
1017 *Surface Passage, Upgrade to Adjustable Spillway Weirs, Lower Granite Trap Modifications*, and
1018 *Lower Snake Ladder Pumps* measures. The structural measures could have localized, short-term
1019 effects to recreation during the anticipated 2-year period when construction occurs in
1020 proximity to the recreation sites close to dams. Effects could include disruption at project sites,
1021 noise, potential traffic congestion, and access limitations during the construction period.

1022 **Water-Based Recreational Visitation**

1023 Anticipated changes in water surface elevations under MO1 would affect boat ramp
1024 accessibility at Dworshak Reservoir in Region C relative to the No Action Alternative. Other
1025 reservoirs in the region would not be affected. Dworshak reservoir levels differ from the No
1026 Action Alternative in the summer months; median reservoir levels are 3 to 6 feet lower from
1027 late June through mid-August, and as much as 8 feet higher in September. As a result, there
1028 would be an anticipated decrease in boat ramp accessibility in August and an increase in
1029 September, but no changes to ramp accessibility in other months at Dworshak Reservoir.

1030 Due to changes in boat ramp accessibility (both decreases and increases), water-based
1031 recreational visitation would be anticipated to decrease by less than 1 percent (approximately
1032 1,000 visits) annually in a typical year. In a high-water year (i.e., 25th percentile) water-based
1033 visitation would increase by less than 1 percent. In a low-water year (i.e., 75th percentile),
1034 water-based visitation would decrease by about 1.3 percent. Reductions in social welfare
1035 associated with the visitation change in a typical year are anticipated to be about \$13,000.

1036 In addition to changes in reservoir elevations, river flows and stages in the region would change
1037 relative to the No Action Alternative. These changes could affect in-river activities like fishing,
1038 rafting, and paddling. While beneficial and adverse effects under MO1 are anticipated to be
1039 minor in most river areas, they could be major in some cases. Changes to flows and stages
1040 along the Clearwater River below Dworshak Dam occur in the summer. Specifically, median
1041 monthly outflows from Dworshak and at the Spalding gage would decrease by 51 and 42
1042 percent, respectively, in August and increase in September by 97 and 71 percent, respectively.
1043 This may change the timing and quality of recreation in the Clearwater River, particularly fishing
1044 (e.g., trout, whitefish), due to increased turbidity, which is most popular in that stretch
1045 according to a Corps resource manager at Dworshak (Corps 2019). If recreationists are unable
1046 to adapt to these changes along the Clearwater River, moderate social welfare effects could
1047 occur in August and September. At the Clearwater and Snake River confluence and Lower
1048 Granite, Little Goose, Lower Monumental, and Ice Harbor Dams, flows would decrease by 16 to
1049 17 percent in August. These changes in flows may affect recreation near the dams, but likely
1050 not in the broader reservoirs. Smaller changes in river flows and stages (less than 10 percent)
1051 would occur elsewhere during peak recreation season in Region C.

1052 **Quality of Recreational Experience**

1053 Changes in the quality of recreational experience are anticipated to be negligible to minor and
1054 adverse in Region C under MO1. As described in Section 3.5, *Aquatic Habitat, Aquatic*
1055 *Invertebrates, and Fish*, returns of salmon and steelhead would be similar to the No Action
1056 Alternative in Region C. Minor increases in median abundance of Snake River spring-run
1057 Chinook salmon would occur in the middle and south forks of the Salmon River (tributaries to
1058 the Snake River upstream from Lewiston, Idaho). Likewise, resident fish in the lower Snake
1059 River reservoirs would see minor effects under MO1 but populations would be similar to the No
1060 Action Alternative. These seem to be minor changes that would not likely be noticeable to most

1061 recreational anglers. Given this, negligible changes in recreational fishing related to changes in
1062 fish populations are anticipated under MO1 relative to the No Action Alternative.

1063 In Region C, MO1 would cause cooler water temperatures in June, July, and September, and
1064 warmer temperatures in August. Warmer water temperatures may make summer recreation
1065 more enjoyable for people who prefer warmer water for rafting and boating. Due to warmer
1066 water temperatures, however, the river stretch between Lower Granite and Ice Harbor Dams
1067 could experience increased algae blooms and higher coliforms and other microbes in
1068 embayments and swim beaches. August is one of the most popular months for water
1069 recreationists, so this may diminish the quality of the recreation experience in this stretch of
1070 river during this time of year and lead to health and safety concerns.

1071 As described in Section 3.6, *Vegetation, Wildlife, Floodplains, and Wetlands*, in Region C, the
1072 wildlife and vegetation conditions along the lower Snake River would be similar under MO1 as
1073 under the No Action Alternative. As such, changes to recreation associated with changes to
1074 wildlife are not anticipated in Region C under MO1.

1075 **Region D – McNary, John Day, The Dalles, and Bonneville Dams**

1076 Under MO1, operational measures impacting recreation in Region D include the *Increased*
1077 *Forebay Range Flexibility* measure and the *Predator Disruption Operations* measure. Structural
1078 measures impacting recreation in Region D include the *Improved Fish Passage Turbines*,
1079 *Additional Powerhouse Surface Passage*, and *Modify Bonneville Ladder Serpentine Weir*
1080 measures. Similar to Region C, structural measures included for Region D projects could have
1081 localized, short-term effects to recreation during the anticipated 2-year period when
1082 construction occurs in proximity to the recreation sites close to dams. Effects could include
1083 disruption at project sites, noise, potential traffic congestion, and access limitations during the
1084 construction period.

1085 ***Water-based Recreational Visitation***

1086 Changes in water surface elevations and river flows are expected to be sufficiently minor as not
1087 to affect recreational access and visitation at recreation sites at the four reservoirs and river
1088 reaches in Region D.

1089 ***Quality of Recreational Experience***

1090 Changes in the quality of recreational experience are anticipated to be negligible in Region D
1091 under MO1. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*,
1092 changes in instream survival of modeled resident fish species are not anticipated to be
1093 statistically different under MO1 when compared to the No Action Alternative in Region D.
1094 Minor increases in median abundance of Snake River spring-run Chinook and steelhead are
1095 anticipated from the mouth of the Snake River to Bonneville Dam. Minor changes in median
1096 abundance of upper Columbia River spring-run Chinook (increase) and steelhead (decrease) are
1097 also anticipated from the mouth of the Snake River to Bonneville Dam. These changes are likely

1098 not enough to change recreational fishing conditions. As such, no changes in recreational
1099 fishing are anticipated under MO1 relative to the No Action Alternative.

1100 Between Ice Harbor and McNary Dams, MO1 would result in cooler water temperatures in
1101 June, July, and September, and warmer temperatures in August. The warmer August waters
1102 could result in increased algal blooms, and increased coliforms and other microbes in
1103 embayments and swim beaches, as compared to the No Action Alternative. August is one of the
1104 most popular months for water recreationists, so this may diminish the quality of the recreation
1105 experience in this stretch of river during this time of year and lead to health and safety
1106 concerns. Downstream of McNary Dam, negligible effects to water quality are anticipated
1107 under MO1.

1108 Negligible to minor changes in vegetation and habitat conditions for wildlife are anticipated in
1109 Region D under MO1. Approximately 4 acres of nesting habitat for waterbirds may be
1110 inundated during April and May in Lake Umatilla; the delay in availability of nesting habitat has
1111 some potential to affect the overall reproductive success of these birds. However, these
1112 changes are not anticipated to substantially affect populations in a manner that would be
1113 readily observable to recreationists or hunters. Other wildlife populations are not anticipated to
1114 be affected under this alternative. As such, negligible changes in recreation associated with
1115 changes in wildlife abundance are anticipated in Region D under MO1.

1116 **REGIONAL ECONOMIC EFFECTS**

1117 As a result of changes in boat ramp accessibility, recreational expenditures associated with non-
1118 local visitation at Lake Koochanusa and Hungry Horse in Region A would decrease annually by
1119 \$12,000 under MO1. Recreational expenditures associated with non-local visitation at Lake
1120 Roosevelt in Region B would decrease annually by \$235,000 under MO1. Recreational
1121 expenditures associated with non-local visitation at Dworshak Reservoir in Region C would
1122 decrease annually by \$54,000 under MO1. Additional regional economic effects, particularly
1123 around Orofino, could occur due to large changes in flows along the Clearwater River in August
1124 and September during typical years. No changes to visitation are anticipated in Region D under
1125 MO1 relative to the No Action Alternative. These changes represent less than 1 percent of non-
1126 local recreational expenditures in the Basin under the No Action Alternative. Overall, the
1127 change in regional expenditures and the regional economic implications of those changes
1128 would be negligible to minor, resulting in approximately 4 fewer jobs, \$139,000 less in labor
1129 income, and \$404,000 less in sales. Over time, visitors would likely adjust their behavior to
1130 adapt to the minor anticipated changes in accessibility, such as utilizing different sites on the
1131 system. These long-term adaptations would reduce effects to visitation.

1132 **OTHER SOCIAL EFFECTS**

1133 Because of the modest anticipated changes to visitation described in the social welfare
1134 evaluation and the minor improvements to fish populations anticipated under MO1, changes in
1135 other social effects are not anticipated under MO1. A localized exception may exist along the
1136 Clearwater River in Region C where major social effects could occur to recreational anglers who

1137 could be displaced by changes in outflows and increased turbidity from Dworshak Dam in
1138 August and September under MO1.

1139 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 1**

1140 Overall effects of MO1 on recreational visitation are anticipated to be negligible to minor, with
1141 the exception of moderate adverse effects to recreational fishing in the Clearwater Reach
1142 below Dworshak Dam in August and September. Table 3-261 presents a summary of MO1
1143 effects, including the anticipated changes in average annual recreational visitation, social
1144 welfare, and regional economic effects by region and in total relative to the No Action
1145 Alternative. For a comparison of anticipated social welfare and regional economic effects across
1146 alternatives refer to Table 41 in Appendix M. Across the Basin, total recreational visitation and
1147 associated social welfare effects are anticipated to decrease by less than 1 percent annually
1148 (approximately 7,500 visits and \$107,000) in a typical year associated with changes in boat
1149 ramp access. Expenditures associated with non-local visitation would decrease by \$300,000
1150 annually across the region, a change of 0.1 percent compared to the No Action Alternative.
1151 Regional economic effects of this change in expenditures would be negligible. The largest
1152 reservoir effects are anticipated at Lake Roosevelt in Region B, the most visited of the four
1153 reservoirs.

1154 There would be negligible to minor benefits to fish populations. Effects to the quality of fishing,
1155 hunting, wildlife viewing, swimming, and water sports at river recreation sites in the region
1156 under MO1 would be negligible. However, there is the potential for moderate adverse effects
1157 to recreational fishing along the Clearwater River in August and September due to increased
1158 turbidity from changes in outflows from Dworshak Dam.

1159 Over time, visitors may adjust their behavior to adapt to changes in accessibility and site
1160 quality, such as utilizing different sites on the system. These long-term adaptations could
1161 reduce effects to visitation.

1162

1163 **Table 3-261. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 1 Relative to the No Action**
1164 **Alternative**

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region A	A reduction of less than 300 water-based recreational visits (less than 1 percent of regional water-based visitation) would occur at Lake Koochanusa and Hungry Horse Reservoirs in a typical year associated with changes in boat ramp access. In high-water-level years, water-based visitation would increase by less than 0.2 percent at these two reservoirs and would increase by less than 0.5 percent in low-water-level years. Annual social welfare benefits would decrease by \$2,700 in a typical year. Negligible effects to the quality of recreation experiences.	Expenditures associated with non-local recreational visits would decrease by \$12,000 across the region (less than 0.1 percent) associated with changes in boat ramp access. Regional economic effects of this change in expenditures would be negligible.	Negligible change from NAA
Region B	A reduction of approximately 6,100 water-based visits at Lake Roosevelt (less than 1 percent of water-based visitation at the site) would occur in a typical year. In years with high or low water, visitation would decrease by 3 to 1.5 percent, respectively. Annual social welfare benefits would decrease by approximately \$91,000 in a typical year. Negligible effects to the quality of recreation experiences.	Expenditures associated with non-local recreational visits would decrease by \$235,000 across the region (0.3 percent) associated with changes in boat ramp access. Regional economic effects of this change in expenditures would be negligible.	Negligible to minor decrease in recreationist well-being when compared NAA due to potential reduction in visitor days and potential minor decreases in wildlife viewing.
Region C	A reduction of approximately 1,000 water-based visits at Dworshak Reservoir (less than one percent of water-based visitation at the site) would occur in a typical year. Visitation would increase by less than one percent in high-water years and decrease by 1.3 percent in low-water years. Annual social welfare benefits would decrease by approximately \$13,000 in a typical year. Negligible to minor effects to quality of fishing, hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions may occur. There is the potential for moderate adverse effects to recreational fishing along the Clearwater River in August and September due to increased turbidity from changes in outflows from Dworshak Dam.	Expenditures associated with non-local recreational visits would decrease by \$54,000 across the region (less than 0.1 percent) associated with changes in boat ramp access. Regional economic effects of this change in expenditures would be negligible.	Negligible change from NAA, with a localized exception along the Clearwater River in Region C where recreational anglers may be unable to fish due to increased turbidity.
Region D	No changes in reservoir visitation associated with changes in boat ramp access. Minor effects to quality of fishing, hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions may occur.	No changes in visitor expenditures or regional effects associated with changes in boat ramp access.	No change from NAA

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Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Total	<p>Negligible effects to reservoir visitation (7,500 fewer visits, representing approximately 0.1 percent of total visitation compared to NAA) in a typical year, with decreases in social welfare of approximately \$107,000 annually associated with changes in boat ramp access.</p> <p>Negligible to minor effects in most areas to quality of fishing, hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions may occur. There is the potential for moderate adverse effects to recreational fishing along the Clearwater River in Region C.</p>	<p>Expenditures associated with non-local recreational visits would decrease by \$300,000 across the region (a change of less than 0.1 percent from No Action) in a typical year associated with changes in boat ramp access. Regional economic effects of this change in expenditures would be negligible (approximately \$404,000 less in sales, four fewer jobs, and \$139,000 less in labor income).</p>	<p>Recreation would continue to provide other social effects associated with considerable recreational opportunities in the region. Continued operation of the system would provide benefits to community well-being, cohesion, and identity. Negligible change from NAA in most locations, with the exception of potential minor effects to recreationists in Region B, and potential major adverse localized social effects to anglers in the Clearwater River in Region C, and potential minor effects to recreationists in Region B.</p>

1166 **3.11.3.4 Multiple Objective Alternative 2**

1167 MO2 includes substantial operational changes to Libby, Hungry Horse, and Grand Coulee Dams,
1168 as well as some changes to operations at the lower Snake and lower Columbia River projects.
1169 The anticipated changes in water surface elevations at Lake Koochanusa, Hungry Horse
1170 Reservoir, Lake Roosevelt, and Dworshak Reservoir are anticipated to affect boat ramp
1171 accessibility for some periods of time during the year, and hence, access and visitation for some
1172 water-based visitors. Water quality and fishing conditions within reservoirs as well as in some
1173 stream reaches below reservoirs may also be affected under MO2. The effects of MO2 on
1174 recreation due to changes in the above resources are described for each region.

1175 **SOCIAL WELFARE EFFECTS**

1176 The focus of effects on water-based recreational visitation in this section are described as
1177 annual effects that would occur after implementation of MO2. Over time, visitors may adjust
1178 their behavior to adapt to changes in accessibility and site quality, such as utilizing different
1179 sites on the system. These long-term adaptations could reduce reported effects.

1180 **Region A – Libby, Hungry Horse, and Albeni Falls Dams**

1181 Under MO2, measures impacting recreation in Region A include Modifying Draft at Libby,
1182 establishing a single *December Libby Target Elevation*, and implementing a *Sliding Scale at Libby*
1183 *and Hungry Horse*. The Libby and Hungry Horse projects would be operated based on local
1184 water supply conditions to allow water managers more flexibility to balance local resident fish
1185 priorities in the upper basin with downstream flow augmentation. In addition, Libby, Hungry
1186 Horse, and Albeni Falls would be operated with slightly more flexibility for hydropower
1187 generation by relaxing restrictions on seasonal pool elevations at the storage projects. Libby
1188 would also be operated to improve reservoir space to balance local and system FRM needs,
1189 temperature management, and operational flexibility for releases in the spring and summer.

1190 No construction activities would occur in Region A under MO2. Therefore, the effects to
1191 recreation in the short term would be similar to the longer-term effects described in the
1192 sections below.

1193 ***Water-based Visitation***

1194 Anticipated changes in water surface elevations under MO2 would affect boat ramp
1195 accessibility relative to the No Action Alternative at Lake Koochanusa (Libby Dam) and Hungry
1196 Horse Reservoir in Region A for some periods of time in a typical year. This change in
1197 accessibility could affect visitation to these sites. Changes in water levels at other reservoirs in
1198 the region would not affect accessibility and visitation. Due to changes in project outflows,
1199 recreational activities occurring in river reaches downstream of Libby Dam and Hungry Horse
1200 Dam could cause both beneficial or adverse localized effects, or both depending upon the river
1201 recreation activity.

1202 At Lake Koocanusa, median water surface elevations would be lower for the majority of the
1203 year under MO2 relative to the No Action Alternative, with the largest decreases in December
1204 and January, when the median decreases are about 12 and 10 feet, respectively. However, the
1205 largest decreases in accessibility would occur in March and April, when median water surface
1206 elevations decrease by about 3 and 2 feet, respectively. Almost 80 percent of visitation to Lake
1207 Koocanusa occurs from May to September, when there are no changes in accessibility under
1208 MO2 relative to the No Action Alternative. Changes in boat ramp accessibility during other
1209 months would reduce water-based visitation by less than 1 percent (approximately 316 visits)
1210 annually in a typical water year. In a high-water-year (i.e., 25th percentile) annual water-based
1211 visitation would decrease slightly (less than 0.4 percent) relative to the No Action Alternative
1212 high-water year. In a low-water year (i.e., 75th percentile), annual water-based visitation would
1213 increase slightly (less than 0.5 percent) relative to the No Action Alternative low-water year.

1214 At Hungry Horse Reservoir, median water surface elevations would be lower for the first 6
1215 months of the year under MO2 relative to the No Action Alternative, with monthly decreases as
1216 large as 8 feet relative to the No Action Alternative. The lower water surface elevations would
1217 result in decreased boat ramp accessibility in January to June at Hungry Horse Reservoir.
1218 However, changes in accessibility in January to April would not be expected to result in changes
1219 in visitation because most visitation occurs between May and September at Hungry Horse.
1220 Water-based visitation at Hungry Horse would decrease by approximately 1 percent (21 visits)
1221 annually in a typical year, which would also occur in high- and low-water-level years. Changes in
1222 social welfare value associated with visitation changes at both sites would be about \$3,500 in a
1223 typical year.

1224 In addition to changes in reservoir elevations, river flows and stages in the region would change
1225 relative to the No Action Alternative. Increased occurrence of higher flows may create localized
1226 water turbidity and adversely affect nearby in-river recreational fishing activities. However,
1227 rafting and paddling activities may be beneficially affected. Both positive and adverse effects
1228 under MO2 are anticipated to be minor in river areas. The largest change in monthly median
1229 outflow from Libby Dam during peak recreation season is a decrease of 30 percent in May
1230 relative to the No Action Alternative. At Bonners Ferry, further down the Kootenai River, flows
1231 and stages change most in winter months when visitation is low. Outflows from Hungry Horse
1232 and SKQ Dams in the Flathead River would be unchanged in summer months except in June
1233 when median outflows decrease by 71 percent at Hungry Horse and 10 percent at SKQ Dam.
1234 Smaller changes in river flows and stages (i.e., less than 10 percent) would occur elsewhere
1235 during peak recreation season in Region A under MO2.

1236 ***Quality of Recreational Experience***

1237 Changes in the quality of recreational experience are anticipated to be minor in Region B under
1238 MO2. Higher flows and reduced reservoir elevations at Hungry Horse Dam/Reservoir could lead
1239 to reductions in zooplankton and other food sources, impacting resident fish populations under
1240 MO2. Fish populations could also be affected by increased entrainment and greater exposure to
1241 predation and angling during upstream spawning migrations. Winter flows in the South Fork

1242 Flathead River below Hungry Horse would be roughly double what they would under the No
1243 Action Alternative, resulting in reduced habitat and more difficult fishing conditions because of
1244 high velocities. Implementation of MO2 at Hungry Horse Dam on the Flathead River may lead to
1245 an increased exposure of wildlife to predation when the reservoir is drawn down, which may
1246 have minor adverse effects to recreational hunting and viewing of wildlife species.

1247 Implementation of MO2 at Albeni Falls Dam (Lake Pend Oreille) would result in changes to
1248 elevation on the Pend Oreille River downstream of the dam, which would have minor adverse
1249 effects on vegetation and nesting habitat available to aquatic and terrestrial wildlife. However,
1250 shorebirds would benefit from increased foraging habitat availability on exposed mudflats.

1251 Resident fish species may be adversely impacted from higher winter flows anticipated under
1252 MO2 downstream of Libby Dam. These higher flows could reduce zooplankton productivity
1253 (food availability for fish) and impact the natural cooling of the river downstream of Libby Dam
1254 in early winter. MO2 measures could also shift the nutrient levels in Lake Kootenai (Libby
1255 Dam), which could result in increased nuisance aquatic plant and algae growth during the
1256 growing season. If substantial changes in aquatic plant growth and algal blooms occurs, this
1257 could make Lake Kootenai less attractive to recreationists and lead to health and safety
1258 concerns, especially to those interested in swimming and water sports. June flows under MO2
1259 would reduce fish habitat and would likely reduce recruitment below Hungry Horse.
1260 Productivity would also be reduced as the stream would be so low that it would leave cobble
1261 and gravel areas that produce insects dry.

1262 The vegetation, wetland, and wildlife analyses found that changes in water surface elevations
1263 at Lake Kootenai under MO2 would adversely affect waterbird populations, which could
1264 result in minor adverse effects to wildlife viewing opportunities. Conversely, more island
1265 habitats for waterbird nesting would be available at Lake Kootenai and might increase bird-
1266 watching recreation opportunities.

1267 In addition, reduced spring freshet would reduce sturgeon habitat on the Kootenai River in
1268 Region A. The lowered pool elevations at Libby Dam may also allow suspended solids to move
1269 downstream and increase the level of total suspended solids in downstream river areas, which
1270 could result in adverse effects to recreational fishing conditions on the Kootenai River. River
1271 flows on the Kootenai River would be higher in the winter, increasing erosion of the shoreline,
1272 and reducing the area of riparian regeneration and productivity of the aquatic system. Effects
1273 could result in some displacement of wildlife populations that are dependent on forested
1274 wetland habitats.

1275 **Region B – Grand Coulee and Chief Joseph Dams**

1276 Under MO2, measures impacting recreation in Region B include constraining *Grand Coulee*
1277 *Maintenance Operations* and decreasing the *Planned Draft Rate at Grand Coulee*. Grand Coulee
1278 would be managed to improve safety, reliability, and capacity of the power plant and spillway.
1279 *Winter System FRM Space* at Grand Coulee would also be operated to preserve the ability to
1280 operate the reservoirs for FRM purposes. In addition, Grand Coulee and Chief Joseph would be

1281 operated with slightly more flexibility for hydropower generation due to *Slightly Deeper Draft*
1282 *for Hydropower* to meet fluctuations in demand.

1283 No construction activities would occur in Region B under MO2. Therefore, the effects to
1284 recreation in the short term would be similar to the longer-term effects described in the
1285 sections below.

1286 ***Water-based Visitation***

1287 Anticipated changes in water surface elevations under MO2 would affect boat ramp
1288 accessibility at Lake Roosevelt in Region B relative to the No Action Alternative. Other reservoirs
1289 in the region would not be affected. Relative to the No Action Alternative, anticipated water
1290 surface elevations would be lower for most of the year, especially in December through March.
1291 In those months, median water surface elevations would decrease by as much as 5 feet at some
1292 locations. Changes in water elevations in April through November, when over 85 percent of
1293 visitation occurs, would not exceed 1.5 feet. While decreased boat ramp accessibility would
1294 occur at Lake Roosevelt, it would only result in minor changes in visitation because accessibility
1295 effects would not occur during the peak recreation season.

1296 Due to changes in boat ramp accessibility, water-based recreational visitation would decrease
1297 by less than 1 percent (approximately 7,700 visits) annually in a typical year. In a high-water
1298 year (i.e., 25th percentile), visitation would decrease by about 1.6 percent. In a low-water year
1299 (i.e., 75th percentile), visitation would decrease by about 3.4 percent. Changes in social welfare
1300 value associated with the visitation change in a typical year would be about \$115,000. Changes
1301 in river flows and stages between dams would be minor relative to the No Action Alternative
1302 (i.e., changes in flow would be less than 10 percent) and therefore would result in negligible
1303 effects to river recreation.

1304 ***Quality of Recreational Experience***

1305 Changes in the quality of recreational experience are anticipated to be minor in Region B under
1306 MO2. There are a number of possible effects to the quality of the recreational experience from
1307 operational measures at the reservoirs and the river reaches from changes in reservoir
1308 elevations and river flows and associated water quality, water temperatures, and bird, wildlife,
1309 and fish habitats in Region B.

1310 As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, upper Columbia
1311 spring Chinook salmon and steelhead would demonstrate reductions in biological performance
1312 metrics compared to the No Action Alternative under MO2, including a minor decrease in
1313 abundance. Reductions in anadromous fish populations could adversely affect recreational
1314 conditions in Region B under MO2. In Lake Roosevelt resident fish, increased entrainment risk
1315 for some species (bull trout, kokanee, rainbow trout, burbot) and changes in tributary access
1316 for trout spawning could adversely affect the destination fishery at Lake Roosevelt.

1317 Lake Roosevelt would experience some improved water clarity from the slower *Planned Draft*
1318 *Rate at Grand Coulee* under MO2 in Region B, including reduced levels of total suspended solids
1319 and turbidity. While current water clarity is generally good at Lake Roosevelt, the improved
1320 water clarity could marginally improve the recreational experience for picnickers, swimmers,
1321 boaters, and campers. Changes to other water quality conditions that would affect recreation
1322 are not anticipated in Region B under MO2. Lake Roosevelt would experience negligible
1323 changes to wildlife during the growing season. During the winter, lower water surface
1324 elevations may decrease open water habitat and access to aquatic vegetation for foraging loons
1325 and other waterfowl. Additionally, there would be some impact to predator-prey relationships;
1326 bighorn sheep and deer would be at a greater risk to mountain lion and wolf populations.
1327 Slightly lower populations of deer and other ungulates could have some minor adverse effects
1328 on hunting conditions in this area.

1329 **Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams**

1330 Within Region C, measures included under MO2 are focused on both structural and operational
1331 changes to the projects. Structural measures occur at the four lower Snake River projects, while
1332 only operational measures would occur at Dworshak. All five of the projects in Region C would
1333 be operated with slightly more flexibility for hydropower generation due to *Full Range*
1334 *Reservoir Operations, Slightly Deeper Draft for Hydropower, and Full Range Turbine Operations*
1335 measures. Operational measures would also occur at the Lower Snake River projects to limit
1336 *Spill to 110% TDG and Increase Juvenile Fish Transportation*. Like in Regions A and B, these
1337 changes would be similar over the 50-year period of analysis, with the bulk of the effects
1338 occurring at Dworshak Reservoir. However, as noted above, recreationists may adjust their
1339 behavior over time, which would reduce effects on visitation.

1340 At all four lower Snake River projects, the *Turbine Strainer Lamprey Exclusion* measures would
1341 be installed. At Little Goose and Lower Granite projects, the *Bypass Screen Modifications for*
1342 *Lamprey* measure would be used to prevent lamprey impingement. Three of the Lower Snake
1343 River projects (Lower Granite, Lower Monumental, and Ice Harbor) would Upgrade to
1344 Adjustable Spillway Weirs for greater operational flexibility to improve juvenile salmon and
1345 steelhead survival. At Ice Harbor, Additional Powerhouse Surface Passage would be constructed
1346 to increase juvenile salmon and steelhead fish passage survival. In addition, *Fewer Fish Screens*
1347 would be installed at Ice Harbor, increasing the efficiencies of hydropower turbines. *Lower*
1348 *Snake Ladder Pumps* would be installed to provide cooler water for adult fish ladders at Lower
1349 Monumental and Ice Harbor Dams.

1350 Similar to MO1 Region C, construction of the structural measures at the four lower Snake River
1351 projects could have minor, localized, short-term effects to recreation during the anticipated 2-
1352 year period when construction occurs in proximity to the recreation sites close to the dams.
1353 Effects could include disruption at project sites, noise, potential traffic congestion, and access
1354 limitations during the construction period.

1355 ***Water-based Visitation***

1356 Anticipated changes in water surface elevations under MO2 would affect boat ramp
1357 accessibility at Dworshak Reservoir in Region C. Other reservoirs in the region would not be
1358 affected. Relative to the No Action Alternative, anticipated median water surface elevations
1359 would decrease by 8 to 26 feet from January to May, 6 feet in June, 4 feet in July, and 2 feet or
1360 less the rest of the year. As a result, decreased boat ramp accessibility would occur from
1361 January to May, reducing accessibility by approximately 10 to 30 percent relative to the No
1362 Action Alternative. Accessibility effects are negligible in other months.

1363 Four of the seven analyzed boat ramps (Bruce's Eddy 1 and 2, Canyon Creek, and Grandad) are
1364 projected to lose 2 to 6 days of accessibility under MO2, while Freeman Boat Ramp at
1365 Dworshak State Park, one of the more popular ramps at the reservoir, would experience the
1366 greatest adverse effects. The ramp would become inaccessible from mid-January to early May
1367 (when about one-third of visits occur at the reservoir) relative to the No Action Alternative,
1368 losing a total of 102 accessible days.

1369 Due to changes in boat ramp accessibility at Dworshak Reservoir, water-based recreational
1370 visitation would decrease by 6.5 percent (approximately 12,000 visits) annually in a typical year
1371 compared to the No Action Alternative. In a high-water year (i.e., 25th percentile) visitation
1372 would decrease by about 4.2 percent. In a low-water year (i.e., 75th percentile), visitation
1373 would decrease by about 7.0 percent. Changes in social welfare value associated with the
1374 visitation change in a typical year would be approximately \$135,000.

1375 In addition to these quantified effects for water-based recreation, lower water levels may affect
1376 non-water activities through changes in aesthetics, landscape (e.g., increased size of sandy
1377 beach areas), and other factors. For example, there may be adverse effects to campgrounds
1378 primarily accessed by boat under MO2. Based on conversations with a recreational manager in
1379 the area, accessibility and subsequent visitation to boat-in camp sites typically declines to near
1380 zero when water elevations are below 1,570 feet and declines to a lesser extent when water
1381 levels are below 1,585 feet. Under MO2, there are six additional days when water levels fall
1382 below these thresholds relative to the No Action Alternative, all during peak recreation season
1383 (early June).

1384 In addition to changes in reservoir elevations, river flows and stages in the region would change
1385 relative to the No Action Alternative. However, the largest changes in the region occur in winter
1386 months when recreation is low. In summer months, flows and stages would change by less than
1387 10 percent, except on the North Fork of the Clearwater River (below Dworshak Dam) where
1388 median monthly flow would decrease by 46 percent in June. These changes could affect in-river
1389 activities like fishing, rafting, and paddling, though positive and adverse effects under MO2 are
1390 anticipated to be minor in river areas. Minor changes in river flows and stages (i.e., less than 10
1391 percent) would occur elsewhere during peak recreation season in Region C under MO2.

1392 **Quality of Recreational Experience**

1393 Changes in the quality of recreational experience are anticipated to be minor in Region C under
1394 MO2. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, changes in
1395 instream survival of modeled anadromous fish species would generally decrease under MO2
1396 when compared to the No Action Alternative in Region C. Decreases in median abundance of
1397 Snake River spring-run Chinook would occur. Decreases of in-river survival of Snake River
1398 steelhead are also anticipated. Kokanee in Dworshak Reservoir would be somewhat reduced by
1399 increased entrainment, which could impact recreational fishing. These changes may not be
1400 noticeable to anadromous anglers; these already-rare fish would be somewhat more rare. As
1401 such, effects to recreational fishing are anticipated to be minor under MO2 relative to the No
1402 Action Alternative related to changes in fish populations in Region C.

1403 In Region C, MO2 would result in negligible changes to water temperatures in river and
1404 reservoir areas between Lower Granite Dam and McNary, with some minor warming in the
1405 summer under the driest of water years.

1406 As described in Section 3.6, *Vegetation, Wildlife, Floodplains, and Wetlands*, implementing MO2
1407 would likely result in negligible to minor changes to hunting and wildlife habitat and viewing
1408 opportunities in Region C.

1409 **Region D – McNary, John Day, The Dalles, and Bonneville Dams**

1410 Similar to Region C, MO1 measures for Region D include operational measure and several
1411 structural measures at the four lower Columbia River projects. All four of the projects in region
1412 D would be operated with more flexibility for hydropower generation due to the *Slightly Deeper*
1413 *Draft for Hydropower* and *Full Range Turbine Operations* measures. Changes under MO2 also
1414 limit *Spill to 110% TDG* to better meet power demand. Like in Regions A, B, and C, these
1415 changes would be similar over the 50-year period of analysis. However, as noted above,
1416 recreationists may adjust their behavior over time, which would reduce effects on visitation.

1417 Structural measures included for Region D projects include installing *Improved Fish Passage*
1418 *Turbines* at John Day; constructing a surface passage route for fish at McNary and John Day;
1419 *Upgrading to Adjustable Spillway Weirs at John Day and McNary*; *Modifying Bypass Screen for*
1420 *Lamprey* at McNary to prevent lamprey impingement; and expanding *Lamprey Passage*
1421 *Structures* at Bonneville, The Dalles, and John Day. *Turbine Strainer Lamprey Exclusion* and
1422 *Lamprey Passage Ladder Modifications* would be implemented at all four Lower Columbia River
1423 projects.

1424 Similar to MO1 Region D, construction of the structural measures at the four Lower Columbia
1425 River projects could have minor, localized, short-term effects to recreation during the 2-year
1426 period when construction occurs in proximity to the recreation sites close to the dams. Effects
1427 could include disruption at project sites, noise, potential traffic congestion, and access
1428 limitations during the construction period.

1429 **Water-based Visitation**

1430 Changes in water surface elevations and river flows are expected to be negligible and would not
1431 affect recreational access and visitation at recreation sites at the four reservoirs as well as at
1432 river reaches in Region D under MO2.

1433 **Quality of Recreational Experience**

1434 Changes in the quality of recreational experience are anticipated to be negligible to minor in
1435 Region D under MO2. Under MO2, decreased abundance of Snake River spring Chinook and
1436 Snake River steelhead, upper Columbia River spring Chinook, and decreased in-river survival
1437 rates of upper Columbia River steelhead would adversely affect recreational fishing conditions
1438 on the Columbia River in Region D.

1439 Above McNary Dam in the Snake River, MO2 would result in negligible to minor increases in
1440 water temperatures in the summer. These increased water temperatures could lead to
1441 increased frequency of algae blooms and increased levels of coliforms and other microbes in
1442 embayments and at swim beaches. August is one of the most popular months for recreation, so
1443 this may diminish the quality of the recreation experience in this stretch of river during this
1444 time of year.

1445 Similar to MO1, minor changes in vegetation and habitat conditions for wildlife are anticipated
1446 in Region D under MO2. Some nesting habitat for waterbirds may be inundated during April and
1447 May in Lake Umatilla; the delay in availability of nesting habitat has some potential to affect the
1448 overall reproductive success of these birds. However, these changes are not anticipated to
1449 affect populations in a manner that would be readily observable to recreationists or hunters.
1450 Other wildlife populations are not anticipated to be affected under this alternative. As such, no
1451 changes in recreation associated with changes in wildlife abundance are anticipated in Region D
1452 under MO2.

1453 **REGIONAL ECONOMIC EFFECTS**

1454 As a result of changes in boat ramp accessibility, recreational expenditures associated with non-
1455 local visitation at Lake Koochanusa and Hungry Horse in Region A would decrease annually by
1456 \$15,000 under MO2 associated with changes in boat ramp access. Recreational expenditures
1457 associated with non-local visitation at Lake Roosevelt in Region B would decrease annually by
1458 \$297,000 under MO2. Recreational expenditures associated with non-local visitation at
1459 Dworshak Reservoir in Region C would decrease annually by \$549,000 under MO2. Because
1460 most changes in visitation would occur along the southern portion of Dworshak Reservoir (at
1461 Freeman Creek boat launch, in particular) communities reliant on recreation in that area—
1462 including Orofino—could be adversely affected in Region C. No changes to visitation are
1463 anticipated in Region D under MO2 relative to the No Action Alternative. Overall, minor
1464 regional economic effects would occur due to changes in non-local visitor expenditures across
1465 the Basin, resulting in approximately 11 fewer jobs, \$434,000 less in labor income, and \$1.3
1466 million less in sales. Most of these effects would be concentrated in Region C. As with social

1467 welfare effects, these effects would likely result in the short term, and may be reduced over
1468 time as visitors adjust behavior. If recreationists reduce recreation trips to this region due to
1469 reduced quality of recreation experiences, additional effects could occur.

1470 **OTHER SOCIAL EFFECTS**

1471 Recreation would continue to provide other social effects associated with considerable
1472 recreational opportunities in the region under MO2. Continued operation of the system would
1473 provide benefits to community well-being, cohesion, and identity associated with existing
1474 recreational activities. Because most changes in visitation would occur along the southern
1475 portion of Dworshak Reservoir (at Freeman Creek boat launch, in particular) communities
1476 reliant on recreation in that area—including Orofino—could be adversely affected by decreased
1477 reservoir access. However overall, changes in access to recreation sites would be minor under
1478 MO2. Under MO2 adverse effects to fish species would have adverse effects on the well-being
1479 of those recreationists who value these fish, particularly area tribes.

1480 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 2**

1481 Overall effects of MO2 on recreation are anticipated to be minor in the short and long term
1482 following implementation. Table 3-262 presents a summary of MO2 effects, including the
1483 anticipated changes in average annual recreational visitation, social welfare, and regional
1484 economic effects by region and in total relative to the No Action Alternative. For a comparison
1485 of anticipated social welfare and regional economic effects across alternatives refer to Table 41
1486 in Appendix M. Across the Basin, total visitation and associated social welfare effects are
1487 anticipated to decrease by less than 1 percent (0.2 percent) annually in a typical year
1488 (approximately 20,000 visits and \$253,000) under MO2. Expenditures associated with non-local
1489 recreational visits would decrease by \$861,000 across the Basin. The total economic effects of
1490 this change in regional expenditures would be minor. The largest effects are anticipated at
1491 Dworshak Reservoir in Region C, the second-most visited of the four reservoirs that are
1492 anticipated to have effects on boat ramp accessibility.

1493 Resident fish entrainment would increase in Region A, which could result in minor effects in the
1494 quality of fishing experiences there. In addition, decreases in fish abundance for several
1495 anadromous fish species could result in minor effects in recreational fishing experiences under
1496 MO2 in Regions B, C, and D. There would be additional minor adverse effects associated with
1497 increased algal bloom frequency in some areas, as well as effects to wetlands and waterbird
1498 habitat that could adversely affect wildlife viewing, and swimming at reservoir and river
1499 recreation sites in the region under MO2. If recreationists reduce recreation trips to this region
1500 due to declines in recreation experiences, additional effects could occur.

1501

1502 **Table 3-262. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 2 Relative to the No Action**
1503 **Alternative**

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region A	<p>A minor reduction of less than 350 water-based recreational visits associated with changes in access to boat ramps (less than 1 percent of regional water-based visitation) would occur at Lake Koochanusa and Hungry Horse Reservoirs in a typical year. In high-water-level years, water-based visitation would decrease by 0.4 percent at these two reservoirs and would increase by 0.4 percent in low-water years. Annual social welfare benefits would decrease by \$3,500 in a typical year.</p> <p>Resident fish species may be adversely impacted from higher winter flows anticipated under MO2. There would be additional minor adverse effects to the water quality and waterbird populations.</p>	<p>Expenditures associated with non-local recreational visits would decrease by \$15,000 across the region (less than 0.1 percent change from the No Action Alternative). Regional economic effects of this change in expenditures would be negligible. If recreationists reduce recreation trips to this region due to declines in recreation experiences, additional effects could occur.</p>	<p>Minor decrease in water-based recreation visitor days causing slight reduction in well-being of reservoir recreationist.</p> <p>Potential adverse impacts to fish species could decrease recreational fishing opportunity and reduce well-being of recreationists who value fishing, as well as tribes.</p>
Region B	<p>A reduction of approximately 7,700 water-based visits at Lake Roosevelt (less than 1 percent of water-based visitation at the site) would occur in a typical year associated with changes in boat ramp access. In years with high or low water, visitation would decrease by 2 to 3 percent. Annual social welfare benefits would decrease by approximately \$115,000 in a typical year.</p> <p>Decreases in fish abundance for several anadromous fish species could adversely affect recreational fishing experiences below Chief Joseph Dam.</p>	<p>Expenditures associated with non-local recreational visits would decrease by \$297,000 across the region (0.4 percent changes from the No Action Alternative). Regional economic effects of this change in expenditures would be minor. If recreationists reduce recreation trips to this region due to declines in recreation experiences, additional effects could occur.</p>	<p>Decreased water-based recreation access at Lake Roosevelt could have adverse effects on recreationists.</p> <p>Potential adverse impacts to fish species, particularly below Chief Joseph Dam, could decrease recreational fishing opportunity and reduce well-being of recreationists who value fishing, as well as tribes.</p>

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Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region C	<p>A minor reduction of approximately 12,000 water-based visits at Dworshak Reservoir (6.5 percent of water-based visitation at the site) would occur in a typical year associated with changes to boat ramp access. Visitation would decrease by 4.2 percent in high-water-level years and 7.0 percent in low-water-level years, compared to high-water and low-water NAA water years. Annual social welfare benefits would decrease by approximately \$135,000 in a typical year. Decreases in fish abundance for several anadromous fish species could adversely affect recreational fishing experiences.</p> <p>Minor additional adverse effects to quality of fishing, hunting, wildlife viewing, swimming, and water sports associated with changes in water quality and wetland habitat conditions on the Snake River.</p>	<p>Expenditures associated with non-local recreational visits would decrease by \$549,000 across the region (0.4 percent change from the No Action Alternative) associated with changes in boat ramp access. Regional economic effects of this change in expenditures would be minor. If recreationists reduce recreation trips to this region due to declines in recreation experiences, additional effects could occur.</p>	<p>Decreased water-based recreational access at Dworshak Reservoir could have adverse effects on recreationists. Potential adverse impacts to fish species could decrease recreational fishing opportunity and reduce well-being of recreationists who value fishing, as well as tribes. Similarly adverse effects to hunting, wildlife viewing, swimming, and related activities would reduce the well-being of recreationists who value these activities, as well as tribes.</p>
Region D	<p>No changes in reservoir visitation would occur associated with changes to boat ramp access. Decreases in fish abundance for several anadromous fish species could adversely affect recreational fishing experiences.</p> <p>Negligible to minor adverse effects to quality of fishing, hunting, wildlife viewing, swimming, and water sports would occur associated with minor changes in river conditions on the lower Columbia River.</p>	<p>No changes in visitor expenditures or regional effects associated with changes in boat ramp access. If recreationists reduce recreation trips to this region due to declines in recreation experiences, reductions in regional recreation expenditures could occur.</p>	<p>No change in boat ramp access. Potential adverse impacts to fish species could decrease recreational fishing opportunity and fishing recreationists' well-being.</p>

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Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Total	Negligible to minor adverse effects to reservoir visitation (20,000 fewer visits, representing approximately 0.2 percent of total visitation) in a typical year, with consumer surplus value losses of approximately \$253,000 annually. Minor adverse effects to quality of fishing, hunting, wildlife viewing, swimming, and water sports associated with changing river conditions in river segments below reservoirs.	Expenditures associated with non-local recreational visits would decrease by \$861,000 across the region (0.2 percent change from the No Action Alternative) in a typical year associated with boat ramp access. Regional economic effects of this change in expenditures are likely to be minor (11 fewer jobs, \$434,000 less in labor income, and approximately \$1.3 million less in sales). If recreationists reduce recreation trips to this region due to declines in recreation experiences, additional effects could occur.	Although changes in access to recreation sites would be minor under MO2, adverse effects to fish species may have adverse effects on fishing experiences under this alternative, which, in turn, could have adverse effects on the well-being of those recreationists who value these fish, particularly area tribes.

1505 **3.11.3.5 Multiple Objective Alternative 3**

1506 MO3 would include substantial operational changes to Libby, Hungry Horse, and Grand Coulee
1507 Dams, and smaller changes to operations on the lower Columbia along with the dam breaches
1508 at the four lower Snake River projects. The effects of MO3 on recreation from changes in these
1509 structural and operational measures are described for each region.

1510 **SOCIAL WELFARE EFFECTS**

1511 The effects on recreational visitation in this section are described as annual effects in both the
1512 short term during and after breaching and construction activity as well as in the longer term
1513 when natural river conditions have been established.

1514 **Region A – Libby, Hungry Horse, and Albeni Falls Dams**

1515 Within Region A, measures included under MO3 are focused on operational changes to the
1516 projects and do not include structural modifications or additions. The Libby and Hungry Horse
1517 projects would be operated based on a Sliding Scale for summer drafts to allow water
1518 managers more flexibility to balance local resident fish priorities in the upper basin with
1519 downstream flow augmentation. Hungry Horse Reservoir would include Additional Water
1520 Supply managed to store and release water downstream for the Confederated Salish and
1521 Kootenai Tribe water rights for irrigation and municipal and industrial purposes. In addition,
1522 Libby, Hungry Horse, and Albeni Falls would be operated with slightly more flexibility for
1523 hydropower generation by relaxing restrictions on seasonal pool elevations at the storage
1524 projects. Libby would also be operated to improve reservoir space to balance local and system
1525 FRM needs, temperature management, and operational flexibility.

1526 No construction activities would occur in Region A under MO3. Therefore, the effects to
1527 recreation in the short term would be similar to the longer-term effects described in the
1528 sections below.

1529 ***Water-Based Visitation***

1530 Anticipated changes in water surface elevations under MO3 would affect boat ramp
1531 accessibility relative to the No Action Alternative at Lake Kocanusa (Libby Dam) and Hungry
1532 Horse Reservoir in Region A for some periods of time in a typical year. Changes in water levels
1533 at other reservoirs in the region would not affect accessibility and visitation. Due to changes in
1534 project outflows, recreational activities occurring in river reaches downstream of Libby Dam
1535 and Hungry Horse Dam could cause beneficial or adverse localized effects, or both, depending
1536 upon the river-based recreation activity.

1537 At Lake Kocanusa, median water surface elevations under MO3 would be the same as under
1538 MO2. These water level changes would affect boat ramp accessibility and reduce water-based
1539 visitation by a small amount (less than 1 percent, or approximately 316 visits annually) in a
1540 typical water year relative to the No Action Alternative. In a high-water year (i.e., 25th

1541 percentile) annual water-based visitation would decrease slightly (less than 0.4 percent)
1542 relative to the No Action Alternative high-water year. In a low-water year (i.e., 75th percentile),
1543 annual water-based visitation would increase slightly (less than 0.5 percent) relative to the No
1544 Action Alternative low-water year.

1545 At Hungry Horse Reservoir, median water surface elevations would be lower for the majority of
1546 a typical year under MO3 relative to the No Action Alternative, with daily decreases of up to 7
1547 feet relative to the No Action Alternative. The lower water surface elevations would result in
1548 decreased boat ramp accessibility in every month except July, August, and September when
1549 decreased water levels are small enough not to affect accessibility. Because recreational
1550 visitation typically occurs between May and September at Hungry Horse, changes in boat ramp
1551 accessibility would mostly affect water-based visitation in May and June. Negligible to minor
1552 effects on recreational visitation are expected. Water-based recreational visitation at Hungry
1553 Horse would decrease by approximately 1.3 percent (29 visits) in a typical year. Decreases in
1554 water-based visitation would be less than 1 percent in low- and high-water-level years. Changes
1555 in social welfare value associated with visitation changes under MO3 in a typical year at both
1556 reservoirs would be about \$3,600 lower than the No Action Alternative.

1557 In addition to changes in reservoir elevations, river flows and stages in the region would change
1558 relative to the No Action Alternative. Increased occurrence of higher flows may create localized
1559 water turbidity and adversely affect nearby river-based fishing activities. However, rafting and
1560 paddling activities may be positively affected. Both positive and adverse effects under MO3 are
1561 anticipated to be minor in river areas. The largest change in monthly median outflow from
1562 Libby Dam during peak recreation season is a decrease of 30 percent in May relative to the No
1563 Action Alternative. At Bonners Ferry, further down the Kootenai River, flows and stages would
1564 decrease during most months, though biggest changes occur in winter months when visitation
1565 is low. Outflows from Hungry Horse Dam in the Flathead River would change most during
1566 summer months, with a decrease of 10 percent in May and an increase of 21 percent in August
1567 and September. Smaller changes in river flows and stages (less than 10 percent) would occur
1568 elsewhere during peak recreation season in Region A under MO3.

1569 ***Quality of Recreational Experience***

1570 Changes in the quality of recreational experience are anticipated to be negligible in Region A
1571 under MO3. Similar to MO1, as described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates,*
1572 *and Fish*, there could be some increased resident fish entrainment and reduced food supply at
1573 and downstream of Hungry Horse Dam in Region A under MO3. In addition, high summer flows
1574 would reduce native fish habitat in the Flathead River below Flathead Lake. However, the
1575 majority of fishing activity, which occurs in Flathead Lake, would be minimally affected. None of
1576 these changes seem likely to be noticeable to recreational anglers. Changes at Pend Oreille and
1577 in the Kootenai River would be minimal. No changes to recreation are anticipated on the Clark
1578 Fork River.

1579 Lake Kootenai (Libby Dam) would undergo changes in water surface elevations that could
1580 have a minor effect on water temperatures under MO3, but these changes would be minor and

1581 unlikely to impact the recreational use of the reservoir. It is possible that the operational
1582 changes proposed for MO3 may impact the nutrient levels in Lake Koochanusa, which could
1583 result in increased nuisance aquatic plant and algae growth during the growing season. These
1584 operational changes, however, are minor and only occur during more extreme water years
1585 (high/low water years) which likely would reduce the potential effects to recreational areas. If
1586 substantial changes in aquatic plant growth and algal blooms occurs, this could make Lake
1587 Koochanusa less attractive to visitors and lead to health and safety concerns, especially those
1588 interested in swimming and water sports. Effects to recreation associated with changes in
1589 wildlife abundance are not anticipated in Region A under MO3.

1590 No measurable changes to wildlife habitat around Hungry Horse Dam, the South Fork Flathead
1591 River or Clark Fork Rivers are expected under MO3. At Albeni Falls, water surface elevation
1592 changes may alter aquatic and terrestrial habitats, including adversely affecting forage
1593 availability for shorebirds and other waterbirds that are of interest to recreationists.
1594 Additionally, western grebe colonies would likely experience destabilization of nests and an
1595 overall decrease in reproductive success. Such changes could adversely impact wildlife viewing
1596 recreation at Albeni Falls.

1597 **Region B – Grand Coulee and Chief Joseph Dams**

1598 Within Region B, measures included under MO3 are focused on operational changes to the
1599 projects, and do not include structural modifications or additions. Grand Coulee would be
1600 managed to improve *Grand Coulee Maintenance Operations*, decrease *Planned Draft Rate at*
1601 *Grand Coulee*, and include *Lake Roosevelt Additional Water Supply* measures. In addition, Grand
1602 Coulee and Chief Joseph would be operated with slightly more flexibility for hydropower
1603 generation by relaxing restrictions on pool elevations to meet fluctuations in demand.

1604 No construction activities would occur in Region B under MO3. Therefore, the effects to
1605 recreation in the short term would be similar to the longer-term effects described in the
1606 sections below.

1607 ***Water-Based Visitation***

1608 Changes in water surface elevations and river flows are expected to be negligible to minor
1609 (during winter only), and would not be anticipated to affect recreational access and visitation at
1610 recreation sites at reservoirs and river reaches in Region B.

1611 ***Quality of Recreational Experience***

1612 Changes in the quality of recreational experience are anticipated to be long-term and beneficial
1613 in Region B under MO3. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and*
1614 *Fish*, minor increases in the abundance of key anadromous recreational fishing species are
1615 anticipated in the upper Columbia River under MO3, particularly Columbia River runs of spring-
1616 run Chinook and steelhead. These improved conditions may increase opportunities for fishing
1617 for these species over the long term in Region B below Chief Joseph Dam. Reduced entrainment

1618 risk for some resident species could benefit the destination fishery at Lake Roosevelt. Changes
1619 under MO3 would also decrease stranding of kokanee and burbot eggs at Lake Roosevelt. As
1620 described in Section 3.6, *Vegetation, Wildlife, Floodplains, and Wetlands*, implementing MO3
1621 would result in negligible changes to these resources in Region B. As such, negligible changes to
1622 the quality of recreational experience are anticipated in Region B under MO3.

1623 **Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams**

1624 Within Region C, measures included under MO3 are focused on both structural and operational
1625 changes to the projects. The four lower Snake River dams would be breached, which would
1626 include removing the earthen embankments to facilitate *Lower Snake Infrastructure Drawdown*
1627 measures to adjust to breached conditions. Existing equipment at the lower Snake dams would
1628 not be used for hydropower generation or navigation. Operational measures focused on the
1629 four projects would include *Drawdown Operating Procedures* and *Drawdown Contingency Plans*
1630 to facilitate drawdown and address unexpected issues. Dworshak would be operated with
1631 slightly more flexibility for hydropower generation by relaxing restrictions on ramping rate
1632 limitations (*Ramping Rates for Safety*).

1633 The breaching of the four lower Snake River projects would have major adverse effects on
1634 current recreation in the short term in Region C. The effects are described as annual effects
1635 that would occur at three general periods of time. In the short term, construction and
1636 breaching activities would preclude all land- and water-based visitation to the lower Snake
1637 River region from construction closures, assumed to occur over a 2-year period (see Chapter 1).
1638 Post-dam breach in the short term, after breaching, some areas would reopen to land-based
1639 visitors, and the unique evolving riverine area may draw additional sightseers to the region;
1640 however, water-based recreation at the lower Snake River reservoirs would no longer occur. In
1641 the longer term, near-natural river conditions could return, which would draw visitors to the
1642 region to experience water- and land-based activities associated with the riverine environment.
1643 Although it is uncertain who would own and manage the lands in the lower Snake River,
1644 recreation facilities, infrastructure, and/or recreational access would need to be developed to
1645 facilitate river recreation visitation in the region. Long-term effects to river recreation, although
1646 uncertain, are described in this section by providing a range in potential visitation from
1647 previous studies and analysis.

1648 ***Water-Based Visitation***

1649 Breaching the dams at the four lower Snake River projects in Region C —Lower Granite Dam,
1650 Little Goose Dam, Lower Monumental Dam, and Ice Harbor Dam—would return the lower
1651 Snake River to free-flowing conditions. This substantial change in reservoir and river conditions
1652 would affect existing developed and dispersed recreation areas and associated recreational
1653 activities. Water-based recreation activities would change from lake or flat-water activities to
1654 river-oriented recreation along the lower Snake River. Given the magnitude of these changes,
1655 the shift in usage patterns could take years to settle.

1656 Fishing activities, as well as other recreation types, would be considerably reduced in the short
1657 term during and immediately following breach, but could rebound in the long term as
1658 anadromous fish populations improve. The largest increases in the number of Snake River
1659 salmon and steelhead are projected under MO3. Therefore, fishing for these anadromous
1660 species could increase in the long term in Region C relative to the No Action Alternative. The
1661 value for trips could also increase due to increased abundance and diversity of wild fish.

1662 Construction and demolition activities at these projects during the breaching activities would
1663 limit access during breaching. Most of the existing facilities were developed around the
1664 reservoirs. Pre-dam river stages under dam breaching would range from approximately 8 to 100
1665 feet below current water surface elevations. Existing water-based recreation facilities, such as
1666 boat ramps, swimming beaches, and moorage facilities, were designed to operate within very
1667 specific ranges of water elevations (generally within 5 feet of full pool). If dam breaching were
1668 to occur, none of these facilities could continue to be used without modification or relocation
1669 because river stages would be substantially lower than would be anticipated under the No
1670 Action Alternative. Some facilities, such as marinas and moorage facilities, would likely be
1671 incompatible with river conditions under MO3.

1672 Many lower Snake River recreation areas have upland facilities such as picnic shelters, concrete
1673 walks, and interpretive signs that are located near the existing reservoirs. Although the
1674 activities that occur at these facilities are not water-dependent, the proximity of water
1675 enhances the recreation experience. Some of these facilities, such as picnic tables, could be
1676 moved closer to the river. However, other more permanent facilities such as shade structures
1677 and parking areas may not be able to be relocated because of the need to allow natural riparian
1678 functions to develop along the newly exposed river shorelines. The fish viewing facilities at the
1679 four dams would no longer be functional under the new river conditions. Fish viewing
1680 opportunities could occur at outdoor interpretive displays. Some sites would simply cease to be
1681 used because the features that attracted people would be eliminated, while other sites would
1682 be abandoned because they would be so high above or far away from the river that access
1683 would be difficult and possibly dangerous.

1684 Dispersed recreation use would likely be reduced in the short term, but would likely return
1685 after the breaching activities and in the long term as the river and shoreline stabilize and
1686 natural features form. The action of dam breaching itself may draw some curious visitors in the
1687 short term. Many of the recreational activities that presently occur at existing dispersed sites
1688 could occur at new dispersed sites.

1689 Lake or flatwater-oriented recreation activities, including water skiing, sailing, motorboating (in
1690 fiberglass boats), fishing for some warm-water species, and sightseeing in tour boats that cruise
1691 between Portland and Lewiston, would no longer be possible if breaching were to occur. Some
1692 activities that occur on lakes, such as fishing, swimming, hiking, camping, and wildlife viewing,
1693 could still occur. Breaching the dams would also expand opportunities in the long term for river
1694 recreation activities, such as drift boating, rafting, and kayaking that require, or are more
1695 favorable under, riverine conditions.

1696 The four lower Snake River projects support 0.9 million annual water-based visits, 1.7 land-
1697 based visits, with a total of 2.6 million annual visits overall (i.e., including water- and land-based
1698 visits). This visitation supports \$8.9 million and \$24.5 million in annual consumer surplus value
1699 (social welfare), for water-based and all visitation, respectively. In the short term, major effects
1700 to social welfare would occur associated with the construction and breaching activities, with a
1701 large reduction in consumer surplus value of up to \$24.5 million with major reductions in both
1702 land- and water-based visitors to the area.

1703 After the construction and breaching activities conclude, it is possible that some of the existing
1704 land-based visitation would return, with the potential for up to 1.7 million visitors (land-based
1705 visitors pre-breach). However, the loss of water-based recreation on the lower Snake River
1706 reservoirs would result in major adverse effects in the short term post-dam breach, a decrease
1707 in consumer surplus of \$8.9 million (-36%), compared to \$24.5 million under the No Action
1708 Alternative.

1709 In the long term, both water-based and land-based river recreation would become
1710 reestablished. The future physical condition of the river is uncertain, which would affect its
1711 suitability for supporting specific types of recreational activities (e.g., river rafting). In addition,
1712 it is uncertain how the environment might be managed to achieve other resource goals (e.g.,
1713 fishing regulations and restrictions associated with the ESA-listed species, particularly Chinook
1714 salmon), and the effect these management decisions would have on recreation activities.

1715 Access to the river and its recreational opportunities will be paramount for the reestablishment
1716 of river visitation to the lower Snake River. For example, parking lots, boat launches, new
1717 trailheads, access roads, etc., would need to be developed to facilitate the drawing of visitors to
1718 the region. Post-dam breach, the Corps will not have a role in providing recreation facilities.
1719 However, other Federal, state, or local government agencies, or other entities could relocate
1720 existing recreation areas or extend boat ramps (from reservoir to river) so that water-based
1721 recreation for the river reach could occur in this region. Costs to extend boat ramps in the
1722 region could range from \$100,000 to \$900,000 depending on the materials, length, and other
1723 factors (Corps Cost Engineering Center of Expertise; 2019). Access roads would also need to be
1724 developed. Relocating or developing a new recreation area (similar to Charbonneau and
1725 Fishhook Parks) is estimated to cost approximately \$6 million.

1726 To provide an estimate of the range of potential recreational use levels that may occur in the
1727 long term under MO3 in the lower Snake River area, this section reviews existing data and past
1728 efforts to estimate these effects. The estimates developed suggest that a wide range of
1729 potential changes to river-based recreational visitation could occur following dam breach.
1730 Information sources for this estimate include the 2002 *Lower Snake River Juvenile Salmon*
1731 *Migration Feasibility Report/Environmental Impact Statement* (2002 EIS) and visitation
1732 estimates for other similar rivers in the region.

1733 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact
1734 Statement

1735 For the 2002 EIS, a contingent behavior survey was conducted to estimate how non-fishing
1736 recreation use would change if the four lower Snake River dams were breached. Using results
1737 from this survey, visitation after dam breach was estimated to be 1.5 to 2.7 million annual
1738 recreation days after full recovery of the natural river system, excluding fishing use. Estimates
1739 of fishing visitation specifically for the lower Snake River following dam breach were not
1740 estimated (Corps 2002b, p. I3-65 to I3-66).¹² To provide an updated visitation level, the
1741 visitation was adjusted for changes in the target survey populations since the study was
1742 conducted. Based on population adjustments, the updated visitation would range from
1743 approximately 1.9 to 3.4 million (Table 3-263).¹³

1744 The Corps had a number of concerns about the survey methods and results from the contingent
1745 behavior survey from the 2002 EIS (Corps 2002b, Section 3.2.9). In 2002, the Corps was
1746 concerned that the “potential recreation benefits associated with dam breaching may be
1747 significantly overstated” (Corps 2002b, p. I3-74), and these concerns remain. First, the result
1748 was much higher than visitation estimates for other free-flowing river/unimpounded river
1749 stretches. Second, the results suggested that visitors from California would account for over 30
1750 percent of the visits to a near-natural lower Snake River, even though data for other free-
1751 flowing rivers/unimpounded river stretches suggested that would be unlikely. Other concerns
1752 pertained to representativeness (the target survey response rate was not met), and the
1753 associated potential for nonresponse and strategic bias.¹⁴

1754 Given the Corps’ concerns, Table 3-263 also presents adjusted visitation estimates from the
1755 2002 EIS without California visitors. Without California, visitation estimates would range from
1756 approximately 1.2 to 1.9 million, depending on whether the estimates were adjusted to current
1757 levels and the extrapolation method used. Visitation to the lower Snake River would be limited
1758 by the availability of infrastructure to access river recreational opportunities.

¹² The range reflects uncertainty about how to extrapolate the survey results, so two different methods were used (Corps 2002b, p. I3-61).

¹³ This population adjustment was made based on personal communication with the study author (Loomis 2019) and is consistent with increased participation in non-fishing river activities (e.g., rafting) since the study was done (USFS 2016).

¹⁴ Nonresponse bias arises when respondents differ in meaningful ways from nonrespondents (e.g., respondents were more likely to report changes in visitation to the lower Snake River after dam removal than nonrespondents). Thus, bias would exist when extrapolating survey responses to the target population. Strategic bias can arise when respondents think they can shape future decisions based on their survey responses. For example, respondents who support dam breach (possibly for reasons beyond its impact to their recreation) might exaggerate the number of visits they would take post-breaching (and vice versa for those opposed).

1759 **Table 3-263. Visitation Estimates for the Lower Snake River in the Long-Term, With and**
1760 **Without Adjusting for Population Growth (excludes recreational fishing), from 2002 EIS**

2002 Contingent Behavior Study Region	Total Recreation Visitor Days Demanded, 2002 EIS	Percentage Change in Population (1998–2018)	Total Recreation Visitor Days Demanded, Population-Adjusted
Rural Washington, Estimate 1	406,372	132%	535,066
Rural Washington, Estimate 2	317,280		417,760
Rural Oregon, Estimate 1	3,914	111%	4,331
Rural Oregon, Estimate 2	10,382		11,487
Rural Idaho, Estimate 1	36,846	111%	40,804
Rural Idaho, Estimate 2	29,739		32,933
Rest of Washington, Estimate 1	426,746	130%	556,631
Rest of Washington, Estimate 2	545,190		711,125
Rest of Oregon, Estimate 1	311,071	125%	390,232
Rest of Oregon, Estimate 2	396,671		497,615
Rest of Idaho, Estimate 1	24,328	142%	34,663
Rest of Idaho, Estimate 2	109,127		155,487
Montana, Estimate 1	14,188	119%	16,889
Montana, Estimate 2	49,157		58,514
California, Estimate 1	299,162	120%	358,739
California, Estimate 2	1,268,226		1,520,788
Total, Estimate 1	1,522,627		1,937,354
Total, Estimate 2	2,725,772		3,405,709
Total, Estimate 1 (without California)	1,223,465		1,578,615
Total, Estimate 2 (without California)	1,457,546		1,884,921

1761 Source: 2002 EIS estimates from Table 3.2-7 (Corps 2002b, p. I3-61). Estimates 1 and 2 reflect uncertainty about
1762 how to extrapolate the survey results, so two different methods were used (Corps 2002b, p. I3-61). County-level
1763 population data for 1998, the year of the contingent behavior survey, from state and county intercensal tables:
1764 1990–2000 (Census 2016); county-level population data for 2018, most recent data available, from American
1765 FactFinder (Census 2019). Counties in each survey strata (i.e., study region) are described in the 2002 EIS (Corps
1766 2002b, p. I3-56, I3-61).

1767 Visitation to Other Similar Rivers in the Region

1768 The 2002 EIS evaluated a number of potential additional comparison sites, including areas along
1769 the main Salmon River, middle fork of the Salmon River, and the Hells Canyon stretch of the
1770 Snake River. As stated in the 2002 EIS, “it appears that a near-natural lower Snake River would
1771 offer a very different type of recreation experience to the region’s premier whitewater rivers,
1772 such as the Main Salmon River, the Middle Fork of the Salmon River, and the Hells Canyon
1773 stretch of the Snake River. In addition to whitewater, these rivers also offer a wilderness
1774 experience and spectacular scenery. In terms of accessibility, the range of activities offered, and
1775 scenery, a near-natural lower Snake River would appear to have more in common with the
1776 lower Deschutes River, the Grand Ronde River, or the lower Salmon River. It would, however,

1777 be much larger than these rivers, with about 10 times the flow of the lower Deschutes and
1778 Grand Ronde Rivers, and about 5 times the flow of the lower Salmon River. In addition,
1779 visitation data for these rivers is limited (Corps 2002b, p. 5.13-18).” The 2002 EIS concluded that
1780 “a near-natural lower Snake River would be a fairly unique recreation resource primarily
1781 because of its size, accessibility, and the available range of existing recreation facilities and
1782 activities” (Corps 2002b, p. 5.13-18).

1783 Despite the limitations, an approach for estimating recreational visitation, primarily for fishing,
1784 to the lower Snake River after dam breaching would be to consider estimates of current
1785 visitation to other rivers in the region. The Hanford Reach of the Columbia River and the North
1786 Fork Clearwater River have been identified by Corps personnel as reasonable sites to evaluate
1787 as potentially comparable to future dam breach conditions on the lower Snake River. The
1788 Hanford Reach, which is located below Priest Rapids Dam on the Columbia River in Washington,
1789 and the North Fork Clearwater, which is located above Dworshak Reservoir in Idaho, are
1790 somewhat similar to a near-natural lower Snake River in terms of size, accessibility, and
1791 proximity to local users.

1792 For the Hanford Reach, WDFW has estimates of fishing effort for select anadromous species
1793 (about 30,000–55,000 trips per year; NMFS 2014b; ODFW and WDFW 2018) and traffic count
1794 data for some boat launches in this reach, but no comprehensive estimates of use. The USFWS
1795 does not have visitation numbers for the Hanford Reach National Monument (Haas 2019), a
1796 significant recreation site in the reach. For the 2002 EIS, it was estimated that the Hanford
1797 Reach had 50,000 annual recreational fishing visits (Foster Wheeler Environmental and Harris
1798 2001). Since the Hanford Reach is approximately 50 miles long, this would be equivalent to
1799 approximately 1,000 annual fishing visits per mile.

1800 Recreational visitation data is available from BLM for sites they manage along the Clearwater
1801 River, but visitation data is not available for other sites. The partial visitation data totaled about
1802 80,000 visits in 2018. This would be comparable to the 100,000 visits estimated for this area
1803 when the 2002 EIS was written (Foster Wheeler Environmental and Harris 2001). Since the
1804 North Fork Clearwater is approximately 135 miles long, visitation per mile would be similar to
1805 the 1,000 visits per mile for the Hanford Reach.

1806 Estimating Visitation in the Long Term

1807 As discussed above, the sources available for estimating recreational use levels and activities
1808 along the lower Snake River after dam breaching under MO3 suggest a wide range of estimates
1809 of potential recreational visitation that may occur post-dam breach. Applying the current
1810 estimates of visitation rates to the Hanford Reach or Clearwater River to the 140-mile lower
1811 Snake River without any other adjustments would yield an estimate of approximately 140,000
1812 annual visits that would be anticipated in the lower Snake River in the long term. However, data
1813 for this estimate is primarily fishing-related. Given this, using estimates from these proxy sites
1814 may considerably underestimate future recreational activity on the lower Snake River.

1815 In contrast, applying the results of the contingent behavior study conducted for the 2002 EIS
1816 would yield an estimate that would range from approximately 1.2 to 3.4 million annual visits
1817 (adjusted and unadjusted for population) under MO3 in the long term, depending on whether
1818 or not California estimates are included. As described above, the Corps has expressed concerns
1819 that the 2002 EIS may have overstated recreation benefits from dam breach.

1820 Because the 2002 EIS specifically focused on non-fishing visitation, it would underestimate that
1821 type of recreation. Recreational fishing visitation was not included in the 2002 study due to the
1822 uncertainty around it being an allowable activity, given the current measures to regulate,
1823 protect, and support ESA-listed fish populations and habitat in the region. However, in the long
1824 term, there is the potential for recreational fishing in the lower Snake River. One approach to
1825 estimate long-term visitation post-dam breach would be to combine the proxy site estimates of
1826 0.1 million, which primarily capture fishing visitation, with the estimates from the 2002 EIS. By
1827 doing this, long-term visitation in the lower Snake River could range from 1.3 to 3.5 million
1828 following dam breach for all types of recreational activities (water- and land-based activities). In
1829 comparison to the current water- and land-based visitation on the lower Snake River under the
1830 No Action Alternative of approximately 2.6 million, the long-term visitation estimates would
1831 suggest that visitation to the river reach (both water-based and land-based recreation) could
1832 range from 50 percent lower to 30 percent higher than under the No Action Alternative. As
1833 described above, visitation to the lower Snake River could be limited by and dependent upon
1834 visitors' ability to access the recreational opportunities.

1835 ***Quality of Recreational Experience***

1836 Changes in the quality of recreational experience are anticipated to be adverse in the short
1837 term, but beneficial in the long term. When dams are breached under MO3, reservoir
1838 conditions on the Snake River would transition from reservoir to riverine. This would have
1839 adverse effects on resident fish species that are popular with recreationists, such as walleye,
1840 that prefer reservoir conditions. Conversely, increases in the abundance of key anadromous
1841 recreational fishing species and native resident fish due to dam breach are anticipated to occur,
1842 particularly Snake River runs of spring-run Chinook and steelhead, as discussed above.

1843 In Region C, from Lower Granite Pool to McNary Dam, dam breach would cause brief but
1844 intense periods of murky water. The level of total suspended solids is expected to reach 20,000
1845 mg/L during the breach and remain greater than 5,000 mg/L for a month following each breach.
1846 Elevated sediment concentrations would also occur during spring runoff and other high-flow or
1847 precipitation events following breach for 2 to 7 years. When the riverbed stabilizes, the level of
1848 total suspended solids would return to less than 50 mg/L. The adverse water quality conditions
1849 combined with the changes to access and elevation discussed above would likely preclude
1850 recreational activities immediately following dam breach events and during transition to a
1851 riverine condition.

1852 The vegetation, wetland, and wildlife analyses found that implementing MO3 would result in
1853 adverse as well as beneficial changes to wildlife-viewing opportunities in Region C during the
1854 short and long term. Immediately following dam breach, water surface elevations would drop

1855 drastically, transitioning the habitat from reservoir to riverine. There would be an expected loss
1856 of approximately 1,200 acres of woody vegetation in Region C. White-tailed deer and mule deer
1857 would be adversely impacted because suitable foraging habitat and protective cover would be
1858 destroyed. These effects would limit hunting and wildlife viewing opportunities in the short
1859 term. Waterfowl populations would decrease for several years following dam breach because
1860 of increased predation, weedy growth, and unstable shorelines, which may adversely impact
1861 wildlife recreation. Most migratory songbirds would be adversely impacted by the reduction in
1862 breeding and foraging habitats in the short term. However, some resident and migratory
1863 shorebirds would benefit from increased mudflat exposure in the short term.

1864 According to Section 3.6, *Vegetation, Wetlands, Floodplains, and Wildlife*, historical aerial
1865 imagery of the lower Snake River indicates approximately 1,500 acres of forested and scrub-
1866 shrub habitats would develop after dam breaching. The availability and distribution of upland
1867 habitat would increase by approximately 12,500 acres following dam removal and reservoir
1868 drawdown. As forested wetlands become more established along the new riverbanks, breeding
1869 and foraging habitats would support waterfowl populations. The more contiguous woody
1870 vegetation habitat along the Snake River would improve habitat for upland mammal species
1871 such as elk, bighorn sheep, black bear, and mountain lion, which may increase in numbers over
1872 the long term. With the development of woody vegetation, increased habitat would be
1873 available for owls, cavity-nesting raptors, and fish-eating raptors over time. In the long term,
1874 the quality of the recreation experience would be improved for hunting and wildlife viewing
1875 activities from an increased abundance of wildlife. In addition, some visitors may value a river
1876 experience with more natural river features and landscapes, resulting in a relatively improved
1877 quality of the recreational experience compared to the No Action Alternative.

1878 **Region D – McNary, John Day, The Dalles, and Bonneville Dams**

1879 MO3 measures for Region D include operational measures and several structural measures at
1880 the four lower Columbia River projects. At all four of the projects in Region D, operations would
1881 modify the spring juvenile fish passage spill and *Reduced Summer Spill*. The four projects would
1882 be operated with more flexibility for hydropower generation by relaxing the ramping rate
1883 limitation (*Ramping Rates for Safety*). The operational measures would have similar effects in
1884 the short term and long term, as described in this section, with minimal effects to recreation
1885 resources.

1886 Structural measures included for Region D projects include *Improved Fish Passage Turbines* at
1887 John Day; Additional Powerhouse Surface Passage at McNary; Upgrading to Adjustable Spillway
1888 Weirs at John Day and McNary; modifying Bypass Screens for Lamprey at McNary; and
1889 implementing *Turbine Strainer Lamprey Exclusion* measures at the four projects. At all four
1890 lower Columbia River projects, the *Lamprey Passage Structures* would be expanded to increase
1891 adult lamprey passage success and *Lamprey Passage Ladder Modifications* would incorporate
1892 lamprey passage features. At Bonneville, the flow control fish ladder sections would be
1893 modified to support increased adult salmon and steelhead survival.

1894 Similar to MO1 Region D, construction of the structural measures at the four Lower Columbia
1895 River projects could have localized, short-term, adverse effects to recreation during the 2-year
1896 period when construction occurs in proximity to the recreation sites close to the dams. Effects
1897 could include disruption at project sites, noise, potential traffic congestion, and access
1898 limitations during the construction period.

1899 ***Water-Based Visitation***

1900 Breaching the dams at the four lower Snake River projects would release substantial amounts
1901 of sediment, almost all of which would be deposited in Lake Wallula behind McNary Dam within
1902 the first 2 to 7 years. Seven recreation sites in Lake Wallula—located along the east and south
1903 sides of the Columbia River below the mouth of the Snake River—could be affected by this
1904 sedimentation permanently. These sites include Hat Rock State Park, Hood Park, McNary Yacht
1905 Club, Sacajawea State Park, Walla Walla Yacht Club, Warehouse Beach, and McNary National
1906 Wildlife Refuge. Some boat launches and beaches may be buried in sediment, which would
1907 adversely affect visitation to those areas, while other areas may experience new vegetation and
1908 wetland conditions. In order to address these effects, local entities may need to remove
1909 sediment materials, extend boat launches, and/or modify the recreation sites to adapt to
1910 sediment and potentially new vegetation and wetland conditions, depending on the localized
1911 effects and desired recreation conditions.

1912 The seven affected sites in Lake Wallula support 163,000 water-based visits during a typical
1913 year (5.6 percent of total Region D visitation), which support \$1.5 million in annual consumer
1914 surplus value (social welfare). This social welfare may be considerably reduced immediately
1915 after breaching of the dams and last for up to several years until any issues associated with the
1916 sediment and recreational access are addressed. Some types of visitation may increase, and
1917 some visitors may experience increased fishing success if the abundance of key recreational
1918 species (Snake River runs of spring-run Chinook and steelhead) increases in Region D. Further,
1919 after the breaching, visitors may adapt to the conditions by visiting recreation areas
1920 downstream or in other places not directly impacted by the sedimentation.

1921 Changes in water surface elevations and river flows are expected to be sufficiently minor as not
1922 to affect recreational access and visitation at the other three reservoirs and river reaches in
1923 Region D under MO3.

1924 ***Quality of Recreational Experience***

1925 Changes in the quality of recreational experience are anticipated to be adverse in the short-
1926 term, but beneficial in the long term. Short-term effects of dam breach on the quality of water-
1927 based recreational experience in Region D would be largely adverse for fishing, hunting, and
1928 wildlife viewing opportunities. In addition to access issues discussed above, increased
1929 sedimentation, particularly in the Lake Wallula area, would adversely affect water quality and
1930 would adversely affect wildlife and associated wildlife viewing opportunities. In general, water
1931 quality throughout the Columbia River would be poor in the several years following dam breach

1932 which would decrease foraging opportunities, limit reproductive success for piscivorous birds,
1933 and compromise wildlife viewing opportunities overall.

1934 As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, and above for
1935 Region C, long-term increases in the abundance of key anadromous recreational fishing species
1936 are anticipated to occur due to dam breach under MO3. To the extent that increases in
1937 abundance occur, this would increase opportunities for anadromous recreational fishing
1938 throughout the region on the Columbia River. With the potential for increased abundance of
1939 anadromous fish, recreational wildlife watching activities could benefit if the wildlife prey on
1940 salmon and other anadromous fish.

1941 Increased sediment deposition in Lake Wallula under MO3 would support the development of
1942 wetland habitats in the lower Snake River over the longer term. Wetlands surrounding Lake
1943 Umatilla are expected to experience increases in the breeding of amphibians, reptiles, mammals,
1944 and birds, which may benefit wildlife watching and duck hunting activities over the long term.

1945 **REGIONAL ECONOMIC EFFECTS**

1946 Short-term adverse effects of dam breach on current reservoir recreation facilities and
1947 visitation would be major, with water levels falling substantially below No Action Alternative
1948 conditions and limitations for recreational access during the breach and construction period. A
1949 wide range of businesses that serve visitors would be adversely affected in the short term when
1950 recreationists forego trips to the region. Some facilities, such as marinas and moorage facilities,
1951 that serve water-based visitors would likely be incompatible with river conditions under MO3,
1952 and employment at these businesses would likely be eliminated.

1953 In the short term during construction activities, a decrease of 2.3 million water- and land-based
1954 visitors in Region C could result in decreased visitor spending of \$103 million, a decrease of 83
1955 percent compared to non-local visitor spending under the No Action Alternative. Reduced
1956 visitor spending would result in a decrease of approximately 1,230 jobs, \$39 million in labor
1957 income, and \$147 million in sales during this construction period.

1958 After the construction and breaching period is over, access would be reopened to some of the
1959 recreation areas, and it is likely that a portion of the land-based visitors, such as sightseers,
1960 hikers, and others, would visit the region after construction while the reservoirs transition to
1961 river conditions. A reduction in only the water-based visitors at the reservoirs (land-based
1962 visitation would remain), compared to No Action Alternative, would result in a decrease of
1963 820,000 non-local visitors and \$37.4 million in visitor spending in the region. The decreased
1964 non-local water-based visitor spending would lead to decreases in 450 jobs and \$14 million in
1965 labor income and \$53 million in sales compared to the No Action Alternative.

1966 Although the specific response of visitors to new river conditions is uncertain, the
1967 establishment of near-natural river conditions would result in changes to regional economic
1968 effects over time. In particular, new opportunities for land- and water-based river recreation
1969 and possibly anadromous recreational fishing may offset visitation losses in Region C associated

1970 with reservoir or flatwater-oriented recreation activities, and recreational opportunities may
1971 even increase in the long term relative to the No Action Alternative. Again, river recreation in
1972 the long-term would be dependent on the development of recreational facilities and
1973 infrastructure to facilitate access. Tourism businesses, such as retail, rental businesses, and
1974 service providers, would likely have to adapt to the new type of visitor who may demand
1975 different types of activities, services, gear, and retail merchandise.

1976 "In particular, new opportunities for anadromous recreational fishing opportunities or
1977 other river-based recreation may replace those lost in Region C for lake or flatwater-
1978 oriented recreation activities (e.g., water skiing, sailing, fishing for some warm-water
1979 species) and may even increase in the long term."

1980 Reduced water quality due to increased sedimentation in Region D at water-based recreation
1981 sites in Lake Wallula may render sections of this area unusable to recreationists for a period of
1982 time following dam breach (approximately 2 to 7 years). Non-local visitor expenditures
1983 associated with water-based visitation at affected sites could decrease by up to \$6.1 million
1984 under MO3. The specific site conditions may not preclude visitation entirely, which would
1985 render this estimate higher than would be likely. However, were it to occur, this change would
1986 represent a decrease of 2.6 percent of non-local visitor expenditures on recreation in Region D
1987 relative to the No Action Alternative. Regional economic effects of this change in regional
1988 expenditures, should they occur, would be a reduction of 80 jobs, \$3 million in labor income,
1989 and \$10 million in sales when compared to the No Action Alternative. Effects would likely be
1990 most acute in the short term. Over time, Lake Wallula visitation would likely rebound to levels
1991 similar to the No Action Alternative and could increase if visitation from the lower Snake River
1992 is diverted to this area.

1993 As a result of changes in boat ramp accessibility, recreational expenditures associated with
1994 visitation at Lake Kooncanusa and Hungry Horse in Region A would decrease annually by \$15,000
1995 under MO3. The economic effects of this change in regional expenditures would be negligible.
1996 No changes to visitation or expenditures are anticipated in Region B under MO3 relative to the
1997 No Action Alternative.

1998 As noted above in the social welfare analysis, potential long-term increases in anadromous fish
1999 populations could increase anadromous recreational fishing activities would likely occur in
2000 Regions C and D, drawing additional visitors. Expenditures associated with these increases in
2001 recreational fishing could also accrue.

2002 **OTHER SOCIAL EFFECTS**

2003 The changes in visitation, particularly along the lower Snake River in Region C and in Lake
2004 Wallula in Region D, could produce substantial beneficial changes to other social effects relative
2005 to the No Action Alternative in the long term, despite adverse changes in the short term.
2006 Communities that are heavily reliant economically on visitation to affected sites would be
2007 adversely impacted in the short term. The identity of the local economies would be changed
2008 immediately after the breaching of the dams and for several years depending on when, and the

2009 extent to which, river recreation activities and visitation are established (and access is
2010 developed) on the lower Snake River. People who currently visit the four lower Snake River
2011 projects and sites along the east and south sides of Lake Wallula would be affected. To the
2012 extent that visitors are not able to easily access alternative recreation sites that provide similar
2013 benefits to sites that would be unavailable under this alternative, physical, mental, and social
2014 health benefits of individuals and their communities from recreation in Region C could be
2015 diminished, particularly in the short term.

2016 However, restoration of riverine conditions and increases in anadromous fish species to the
2017 lower Snake River has been a long-term objective of area tribes, who would experience benefits
2018 to their ability to use the area recreationally and exercise treaty rights, in addition to other
2019 cultural and spiritual benefits. Natural landscapes and the transition to a natural river state
2020 would likely provide many people some social benefits, as well as educational and scientific
2021 research opportunities associated with this unique area. These benefits would accrue in
2022 Regions C and D.

2023 Adverse effects to resident fish species in the short term would have adverse effects on fishing
2024 experiences in Region C under this alternative, which, in turn, would have adverse effects on
2025 the well-being of those recreationists who value affected fish, particularly tribes.

2026 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 3**

2027 Adverse effects of MO3 on recreational visitation at the four lower Snake River projects in
2028 Region C are anticipated to be major due to dam breach and construction activities. Some land-
2029 based visitation would return to the region following the construction activities once areas are
2030 opened to recreation. With about one-third of the current visitation associated with water-
2031 based activities, the loss of this visitation would be large and adverse. However, as the river
2032 returns to natural conditions, river-based recreation would increase over time, given that
2033 recreational access and infrastructure is developed; the exact long-term beneficial impacts to
2034 visitation and social welfare are uncertain, although the losses in reservoir recreation would be
2035 offset by increases in river recreation visitors, and may eventually increase to levels and values
2036 greater than under the No Action Alternative. For a comparison of anticipated social welfare
2037 and regional economic effects across alternatives refer to Table 41 in Appendix M.

2038 Water quality effects are expected to be major at Lake Wallula in Region D in the short term
2039 due to temporary sedimentation effects associated with dam breach; water-based visitation
2040 would be adversely affected.

2041 An increased quantity and quality of recreational fishing trips for key anadromous species,
2042 namely Snake River runs of salmon and steelhead, could occur. However, while Section 3.5,
2043 *Aquatic Habitat, Aquatic Invertebrates, and Fish*, describes increased abundance of these
2044 species under MO3, other factors may limit their long-term success (e.g., ceased hatchery
2045 operations on the lower Snake River).

2046 Table 3-264 presents a summary of MO3 effects, including the anticipated changes in average
2047 annual recreational visitation, social welfare, and economic effects by region and in total
2048 relative to the No Action Alternative. Across the Basin in the short term, total recreational
2049 visitation and associated social welfare effects could decrease by up to 21 percent in the study
2050 area (approximately 2.7 million visits and \$26.0 million across all locations).

2051 Expenditures associated with 2.4 million non-local recreational visits could decrease by up to
2052 \$109 million across the Basin in the short term during the breaching and construction activities
2053 (representing 22 percent of non-local visitor expenditures on recreation across the Basin under
2054 the No Action Alternative). The decrease of 2.4 million non-local visitors would result in
2055 decreases of 1,420 jobs, \$59 million in labor income, and \$189 million in sales. The largest
2056 effects would be anticipated at the four lower Snake River projects in Region C and Lake Wallula
2057 in Region D due to dam breach and associated sedimentation effects.

2058 Changes in other social effects could be substantial, as communities that are economically
2059 dependent on visitation to these five projects could be adversely affected, particularly in the
2060 short term. Users of these projects could experience diminished physical, mental, and social
2061 health benefits associated with the reduced quantity or quality of recreational activities (staying
2062 home or diverting recreational use to less-preferred sites), particularly in the short term. The
2063 effects to social welfare, regional economic, and other social effects could be moderated, at
2064 least to some extent, through adaptation of recreationists to new conditions over time (e.g.,
2065 recreationists converting to river-oriented recreation). Restoration of riverine conditions and
2066 increases in anadromous fish species to the lower Snake River has been a long-term objective
2067 of area tribes, who would experience benefits to their ability to use the area recreationally and
2068 exercise treaty rights, in addition to other cultural and spiritual benefits.

2069 **Table 3-264. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 3 Relative to the No Action**
2070 **Alternative**

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region A	A reduction of less than 350 water-based recreational visits (less than 1 percent of regional water-based visitation) would occur at Lake Koochanusa and Hungry Horse Reservoirs in a typical year. In high-water-level years, water-based visitation would decrease by 0.4 percent at these two reservoirs and would increase by 0.4 percent in low-water-level years. Annual social welfare benefits would decrease by \$3,600 in a typical year associated with access to boat ramps. Negligible effects on the quality of fishing experiences.	Expenditures associated with non-local recreational visits would decrease by \$15,000 across the region (less than 0.1 percent change from the NAA). Regional economic effects of this change in expenditures would be negligible. If recreationists reduce recreation trips to this region due to declines in recreation experiences, additional effects could occur.	Negligible change in well-being of water-based recreation visitors due to slight decrease in recreation days. Negligible difference in the well-being of recreationists that value recreational fishing and tribes.
Region B	No changes in reservoir visitation would occur associated with access to boat ramps. Increased effort or enjoyment of recreational fishing for anadromous fish could occur over time as populations increase. Changes in the quality of recreational experience are anticipated to be long term and beneficial.	No changes in visitor expenditures or regional effects associated with access to boat ramps. To the extent that increases in anadromous fish populations draw additional fishing visits to the region, increases in regional economic expenditures and effects could increase in the long term.	No change from NAA
Region C	Overall, long-term beneficial (e.g., riverine-oriented recreation) and adverse (e.g., lake or flatwater-oriented recreation) effects are anticipated.	In the short term, non-local visitor expenditures would decrease by \$103 million during construction and breaching activities, resulting in major adverse effects to regional economic conditions (decrease in 1,230 jobs and \$39 million in labor income). After the construction and breaching period is over, access would be reopened to some of the recreation areas. A reduction in only the reservoir water-based visitors compared to NAA would result in a major decrease in non-local visitor expenditures of \$37 million, with associated decreases in 450 jobs, \$14 million in income, and \$53 million in sales.	Major changes in other social effects would occur, which could be both beneficial and adverse. Communities that benefit economically from recreational visits could be adversely affected, particularly in the short term. However, restoration of riverine conditions and increases in anadromous fish species could benefit recreationists who value river-based recreation activities, as well as possibly recreational fishing and related economic opportunities.

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Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
	<p>Due to dam breaching and construction activities, there would be major short-term adverse effects to all water- and land-based reservoir visitation from construction closures in the short term at the four lower Snake River projects. This could result in a decrease of 2.6 million annual visits on average and \$25 million in social welfare in the short term. Some land-based visitation would return in the short term as access to lower Snake River areas is reopened. The reduction of only water-based reservoir recreation compared to NAA at the lower Snake river would result in a decrease of 0.9 million visitors and \$8.9 million in social welfare.</p> <p>In the long term, as riverine conditions return, river recreation would increase, with benefits to visitation and social welfare values. Access to the lower Snake River would be dependent on the development of new recreation facilities and water access points. Additional costs would be incurred to provide recreational infrastructure.</p> <p>Increased enjoyment of recreational fishing for anadromous fish could occur over time as fish populations increase. The long-term river visitation estimates (land- and water-based) suggest that recreation values could range from 50 percent lower to 30 percent higher than under the No Action Alternative (1.5 to 3.4 million visitor days).</p>	<p>Over time, river recreation would grow, along with the quality of the recreational experience. The newly created river conditions would draw a different pattern of visitors to the region, with different types of visitor spending compared with reservoir visitors. Depending on the numbers and type of visitor, tourism economic activity may partially or fully offset the loss in economic activity associated with reservoir recreation, with the potential for greater economic activity in the region relative to NAA.</p>	<p>The restoration of the Snake River has been a long-term objective of area tribes, who would experience benefits to their ability to use the area recreationally and exercise treaty rights, in addition to other cultural and spiritual benefits.</p> <p>Adverse effects to resident fish species would have adverse effects on fishing experiences in Region C, which, in turn, would have adverse effects on the well-being of those tribes in Region C who value the affected resident fish.</p> <p>Natural landscapes and the transition to a natural river state would likely provide social benefits to many people, as well as educational and scientific research opportunities associated with this unique area.</p> <p>Recreationists whose recreational activities depend on reservoir conditions could experience reduced well-being associated with the reduced availability of reservoir recreation within Region C.</p>

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Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region D	Due to sedimentation effects associated with dam breach, 163,000 annual water-based visits could be lost at seven Lake Wallula recreation sites (5.6 percent of total Region D visitation) in the short term (2 to 7 years). Annual social welfare benefits would decrease by \$1.5 million associated with this change. Some visitation could be replaced or improved through a transition to river-based recreation over time. Short-term adverse and long-term beneficial effects are anticipated. Increased effort or enjoyment of recreational fishing for anadromous fish could occur over time as populations increase.	Expenditures associated with non-local recreational visits would decrease by \$6.1 million (2.6 percent), particularly in the short term (2 to 7 years). Regional economic effects of this change in expenditures would be minor (80 fewer jobs, \$3 million less labor income, and \$10 million less sales). Some adaptation is likely over time. To the extent that increases in anadromous fish populations draw additional fishing visits to the region, increases in regional economic expenditures and effects would increase in the long term.	In the short run, there could be a decrease in water-based recreation visitor days at Lake Wallula, decreasing these recreationists' well-being. Over the long term, depending upon modifications made at several Lake Wallula facilities, well-being of reservoir recreationists would improve. In addition, increased opportunity for recreational fishing for anadromous fish could occur, improving the well-being of recreationists that value this type of fishing.
Total	In Region A, a reduction of less than 1 percent in regional water-based visitation would occur at Lake Koocanusa and Hungry Horse Reservoir in a typical year. Negligible changes in water-based visitation in Region B and Region D. Overall in Region C, long-term beneficial (e.g., riverine-oriented recreation) and adverse (e.g., lake or flatwater-oriented recreation) effects are anticipated. A number of recreation areas on Lake Wallula would be adversely affected by sedimentation from breaching. Basin-wide visitation could decrease by up to 21 percent (approximately 2.7 million visits and \$26 million in annual social welfare benefits). Increased enjoyment of recreational fishing for anadromous fish could occur over time as fish populations increase. The long-term river visitation estimates (land- and water-based) suggest that recreation values could range from 50 percent lower to 30 percent higher than under NAA (1.5 to 3.4 million visitor days).	Expenditures associated with non-local recreational visits could decrease by up to \$109 million across the region (22 percent decrease compared to NAA) in the short term, primarily associated with closures during dam breaching activities. Regional economic effects of this change in expenditures would be major, with 1,420 fewer jobs, \$59 million less labor income, and \$189 million less in sales. In the long term, depending on the numbers and type of visitor, tourism economic activity may partially or fully offset the loss in economic activity associated with reservoir recreation, with the potential for greater economic activity in the region relative to NAA. Increases in anadromous fish populations could draw additional fishing visits to the region in the long term with benefits to regional economic conditions.	Negligible changes in other social effects in Regions A and B compared to the No Action Alternative. In Regions C and D major changes in other social effects could occur, which could be adverse in the short term and beneficial in the long term at the four lower Snake River projects and Lake Wallula.

2072 **3.11.3.6 Multiple Objective Alternative 4**

2073 The additional combination of fish measures that differ from the other MOs include *Spillway*
2074 *Weir Notch Inserts*, changes to the juvenile fish transportation operations (*Spring & Fall*
2075 *Transport* and *No Summer Transport* measures), *Spill up to 125% TDG*, the highest spill target
2076 range considered in this EIS. Other measures include annual *Drawdown to MOP* at the lower
2077 Snake River and Columbia River reservoirs, a measure for establishment of riparian vegetation,
2078 dry year augmentation of spring flow with water stored in upper basin reservoirs, and
2079 Additional Powerhouse Surface Passage for kelt and overshoots.

2080 There are anticipated changes in water surface elevations at Lake Kooconusa and Hungry Horse
2081 Reservoir and Lake Roosevelt during a typical water year. Lake Roosevelt could experience a
2082 longer period of time with reduced boat ramp accessibility, especially during low-water years.
2083 Recreational access is managed by NPS, Confederated Tribes of the Colville Reservation, and
2084 the Spokane Tribe of Indians, therefore the tribal communities around Lake Roosevelt could be
2085 affected by these changes. In addition, during low-water years, there may be accessibility
2086 impacts at Lake Pend Oreille boat ramps, fixed docks, pedestrian ramps at launches,
2087 commercial marinas, community marinas, boat-up restaurants, and fueling and private docks
2088 that need the stable summer elevation of 2,062 feet to function. Water quality and fishing
2089 conditions within reservoirs, as well as in some stream reaches below reservoirs, may also be
2090 affected under MO4. The effects of MO4 on recreation are described in more detail for each
2091 region in the sections below.

2092 **SOCIAL WELFARE EFFECTS**

2093 The focus of effects on water-based visitation in this section are described as annual effects
2094 that would occur after implementation of MO4. Over time, visitors may adjust their behavior to
2095 adapt to changes in accessibility and site quality, such as using different sites in the CRS. These
2096 long-term adaptations could reduce effects on visitation.

2097 **Region A – Libby, Hungry Horse, and Albeni Falls Dams**

2098 Measures included for MO4 for projects within Region A include operational changes only and
2099 are very similar to the operational measures proposed under MO1. These similar measures
2100 include actions like *Modified Draft at Libby*, juvenile fish operations (*Spring & Fall Transport* and
2101 *No Summer Transport*), water management flexibility, and other operations. In addition, MO4
2102 includes limiting *Winter Stage for Riparian* at Bonners Ferry. Similar to MO1, because no
2103 structural measures are planned under MO4, the effect on recreation is directly tied to changes
2104 in water elevations and flows related to operational changes. These changes would be similar in
2105 the short term and longer term, over the 50-year period of analysis.

2106 **Water-Based Recreational Visitation**

2107 Anticipated changes in water surface elevations under MO4 would affect boat ramp
2108 accessibility relative to the No Action Alternative at Lake Kooconusa (Libby Dam) and Hungry
2109 Horse Reservoir in Region A for some periods of time in a typical year. This change in

2110 accessibility would likely affect visitation to these sites. Changes in water levels at other
2111 reservoirs in the region would not affect accessibility and visitation in a typical year. Note, dry
2112 year conditions are different from typical years and are discussed below. Due to changes in
2113 project outflows, recreational activities occurring in river reaches downstream of Libby Dam
2114 and Hungry Horse Dam could cause beneficial or adverse localized effects, or both, depending
2115 upon the river-based recreation activity.

2116 At Lake Koochanusa, median water surface elevations would decrease most of the year under
2117 MO4 relative to the No Action Alternative, but would increase in January, February, May, and
2118 June. These changes would reduce boat ramp accessibility relative to the No Action Alternative
2119 in March and April, and increase accessibility in June and December (little visitation occurs
2120 during December, however). Due to changes in boat ramp accessibility (both decreases and
2121 increases), water-based recreational visitation is estimated to decrease by less than 0.1 percent
2122 (approximately 21 visits) annually under MO4 relative to the No Action Alternative at Lake
2123 Koochanusa in a typical water year. In a high-water year (i.e., 25th percentile) water-based
2124 visitation would increase slightly (0.1 percent) relative to the No Action Alternative high-water
2125 year. In a low-water year (i.e., 75th percentile), water-based visitation would also increase
2126 slightly (0.8 percent) relative to the No Action Alternative low-water year. In these years, the
2127 increased water levels in June are anticipated to lead to increases in visitation that are larger
2128 than anticipated decreases.

2129 At Hungry Horse Reservoir, median water surface elevations would be lower across all months
2130 under MO4 relative to the No Action Alternative, with the biggest decreases of 7 to 9 feet
2131 between October and January. The lower water surface elevations would result in decreased
2132 boat ramp accessibility in every month except July, August, and September. Because
2133 recreational visitation typically occurs between May and September at Hungry Horse, changes
2134 in boat ramp accessibility would lead to changes in water-based visitation in May and June only.

2135 Water-based recreational visitation at Hungry Horse is expected to decrease by 1.4 percent (31
2136 visits) annually in a typical year. In low- and high-water years, visitation at Hungry Horse would
2137 decrease by less than 1 percent and about 2.5 percent, respectively. Changes in social welfare
2138 are anticipated to be about \$500 across Lake Koochanusa and Hungry Horse Reservoir in a
2139 typical year. Negligible to minor effects on recreational visitation would be expected.

2140 In low-water years, water surface elevations at Lake Pend Oreille (Albeni Falls) would be 1 to 3
2141 feet lower between July and September under MO4 relative to the No Action Alternative. While
2142 the analysis does not detect changes in boat ramp accessibility from these changes in water
2143 levels at Federal- and state-managed boat ramps, major adverse effects to recreation
2144 associated with impaired lake aesthetics (e.g., exposed mud flats) and reduced functionality of
2145 fixed docks and other infrastructure are possible under MO4 in low-water years (i.e., low-water
2146 measured at 75th percentile). There are over 2,000 fixed docks, city- and county-managed boat
2147 ramps, and other infrastructure in Lake Pend Oreille that are sensitive to changing lake levels.
2148 The Lake Pend Oreille area is an important regional tourist destination in Region A, supporting

2149 as many as one million visits annually.¹⁵ A substantial proportion of this visitation occurs in
2150 summer months and is water-based. According to Bonner County Assessor's Office, there are
2151 approximately 3,100 waterfront property owners on Lake Pend Oreille and Pend Oreille River,
2152 many of whom are seasonal visitors (Lake Pend Oreille, Pend Oreille River, Priest Lake and
2153 Priest River Commission [Lakes Commission] 2019). The Lakes Commission reports that
2154 accessibility impacts can occur from just a 1-foot drop in lake elevation. For example, the Lakes
2155 Commission reports that at least 80 percent of lakefront homes have fixed infrastructure that
2156 makes mooring a boat difficult and unsafe in low-water conditions. There are also 20 marinas
2157 on the lake (Lakes Commission 2019). The Lakes Commission provided cost information for
2158 various infrastructure modifications that would be needed to accommodate lower water levels
2159 at Lake Pend Oreille. Using this information, the cost of extending fixed and floating docks to
2160 accommodate lower water levels was estimated to be approximately \$4,500 per fixed dock and
2161 \$1,575 per floating dock (both inclusive of a 50 percent contingency). Given this, costs to
2162 extend fixed docks could exceed \$9 million (Lakes Commission 2019). There would be
2163 additional costs for modifying other types of infrastructure including pedestrian ramps at
2164 launches, commercial marinas, community marinas, boat-up restaurants, and fueling docks.

2165 Given this, a 1- to 3-foot decline in water surface elevations has the potential to have major
2166 adverse effects on recreational visitation in low water level years. These effects would reduce
2167 the social welfare benefits associated with recreational visitation at Lake Pend Oreille.

2168 In addition to changes in reservoir elevations, river flows and stages in the region would change
2169 relative to the No Action Alternative. Increased occurrence of higher flows may create localized
2170 water turbidity and adversely affect nearby in-river recreational fishing activities. However,
2171 rafting and paddling activities may be positively affected. Both positive and adverse effects
2172 under MO4 are anticipated to be minor in river areas. The largest changes in monthly median
2173 outflows from Libby Dam during peak recreation season would be a decrease of 17 percent in
2174 May relative to the No Action Alternative and an increase of 23 percent in July. At Bonners
2175 Ferry, further down the Kootenai River, flows and stages change most in winter months when
2176 visitation is low. Along the Flathead River at Hungry Horse Dam and Columbia Falls, the biggest
2177 changes in monthly median outflow during peak recreation season occur in July to September,
2178 when Hungry Horse outflows would increase by up to 37 percent, and flows on the Flathead
2179 River at Columbia Falls would increase by about 20 percent. Smaller changes in river flows and
2180 stages (less than 10 percent) would occur in other parts of Region A during peak recreation
2181 season under MO4.

¹⁵ More detail on boat ramp accessibility under the No Action Alternative including boat ramp accessibility by month is provided in Appendix M.

¹⁵ Available recreation visitation data from Federal and state agencies does not include visitation at city- and county-managed sites or by private landowners along the lake. However given the high volume of visitors to private homes and recreation sites, the number of annual visits is likely to exceed 1 million (Klatt 2019; Lakes Commission 2019).

2182 **Quality of Recreational Experience**

2183 Changes in the quality of recreational experience are anticipated to be adverse in Region A
2184 under MO4. Similar to MO2, reservoir drawdowns and increased flushing rates could reduce
2185 overall food availability and habitat for resident fish species, which could adversely affect
2186 fishing conditions at Hungry Horse and, to a lesser extent, Lake Pend Oreille and the Kootenai
2187 River. Specifically, as described in Section 3.5, Aquatic Habitat, Aquatic Invertebrates, and Fish,
2188 bull trout and Westslope cutthroat trout could have increased entrainment risk and some
2189 reduced habitat and food availability under MO4 in Region A compared with the No Action
2190 Alternative. This could have adverse effects on recreational fishing experiences under MO4 in
2191 Region A relative to the No Action Alternative. Implementation of MO4 at Hungry Horse Dam
2192 may lead to an increased exposure of wildlife to predation when the reservoir is drawn down,
2193 which may impact recreational hunting and viewing of wildlife species. In addition, near-shore
2194 areas used for recreation (such as swimming and non-motorized boating) and river tributaries
2195 may be more difficult to access due to lower lake levels, as well as greater aquatic plant growth.

2196 **Region B – Grand Coulee and Chief Joseph Dams**

2197 Similar to Region A, MO4 measures for Region B are focused on operational changes at the
2198 projects and do not include structural measures. Grand Coulee operational measures include
2199 various flood risk management operations such as Updating System FRM Calculations,
2200 developing *Winter System FRM Space*, and decreasing *Planned Draft Rate at Grand Coulee*.
2201 Chief Joseph operational measures include increased diversions for water supply. In addition, a
2202 Grand Coulee operations measures would be added under MO4 to meet the *McNary Flow*
2203 *Target* by adding additional augmenting flows in the lower Columbia River (in addition to those
2204 that occur under No Action) during juvenile salmon outmigration period in low water years.

2205 **Water-based Recreational Visitation**

2206 Anticipated changes in water surface elevations under MO4 would affect boat ramp
2207 accessibility at Lake Roosevelt in Region B relative to the No Action Alternative. Other reservoirs
2208 in the region would not be affected. Relative to the No Action Alternative, anticipated water
2209 surface elevations would be lower across all months. Lake Roosevelt spans from RM 596 to
2210 about RM 748; between RM 616 and 720 (three of the four H&H index locations where
2211 elevations were estimated), the biggest anticipated decreases in median monthly water levels
2212 would be 8 feet in January and June, 7 feet in February, 6 feet in December, and 5 feet in May.
2213 Smaller changes of 2 to 3 feet would occur in March, July, August, September, and November.
2214 Anticipated decreases follow a similar pattern at the other index location where elevations
2215 were estimated (RM 740), but are generally smaller.

2216 These lower water surface elevations would reduce boat ramp accessibility at 16 of the 22
2217 analyzed boat ramps at Lake Roosevelt. Of these 16 affected boat ramps, 11 would lose 7 to 19
2218 days of accessibility. The remaining 5 boat ramps—Evans, Hawk Creek, Marcus Island, Napoleon
2219 Bridge, and North Gorge—are anticipated to lose 55 to 63 days of accessibility annually in a
2220 typical water level year. The minimum usable elevations for these 5 boat ramps (1,280 or 1,281

2221 feet) are the highest elevations of all boat ramps in the lake. Some other boat ramps are
2222 accessible to as low as 1,222 feet NGVD29. Evans Creek is located near River Mile 635, while
2223 the others are located between River Miles 711 and 722. Thus, most of the effects are
2224 anticipated in the northern part of the reservoir.

2225 The changes under MO4 would result in decreases in boat ramp accessibility of 15 to 18
2226 percent in January, February, and May; 11 percent in June; and 7 percent or less in other
2227 months at Lake Roosevelt. Overall, average annual water-based visitation is expected to
2228 decrease by 6 percent or approximately 45,000 visits at Lake Roosevelt in typical years. Seventy
2229 percent of lost visits occur in May, June, and August, with 28 percent of the total decrease
2230 occurring in June. Smaller losses occur in the other months. In a high-water year (i.e., 25th
2231 percentile) water-based visitation would decrease by over 6 percent (i.e., similar to a typical
2232 year) while in the low-water year (i.e., 75th percent) water-based visitation would decrease by
2233 over 24 percent (a major adverse effect), or about 175,000 visits. The low-water year result is
2234 due to the *McNary Flow Target* measure. Decreased visitation under MO4 in a typical water
2235 year would result in an average annual decrease of \$684,000 in social welfare. In a low-water
2236 year, there would be an average annual decrease of \$2.6 million in social welfare.

2237 Recreational access is managed by NPS, Confederated Tribes of the Colville Reservation, and
2238 the Spokane Tribe of Indians.

2239 In addition to the effects quantified above for water-based recreation, lower water surface
2240 elevations may affect non-water activities through changes in aesthetics and the landscape
2241 (e.g., increased size of sandy beach areas), as well as other factors. These additional effects to
2242 water-based recreation may not be captured in the analysis above (e.g., lower fishing success
2243 due to lower water surface elevations).

2244 In addition to changes in reservoir elevations, river flows and stages in the region would change
2245 relative to the No Action Alternative. Monthly median outflows from Grand Coulee, Chief
2246 Joseph, Wells, Rocky Reach, Rock Island, Wanapum and Priest Rapid Dams are expected to
2247 decrease by up to 11 percent in September relative to the No Action Alternative. These changes
2248 in flows may affect recreation near the dams, but likely not in the broader reservoirs. Smaller
2249 changes in river flows and stages (less than 10 percent) are anticipated elsewhere or at other
2250 times of year in Region B.

2251 ***Quality of Recreational Experience***

2252 Changes in the quality of recreational experience are anticipated to be adverse as well as
2253 beneficial in Region B under MO4. As described in Section 3.5, *Aquatic Habitat, Aquatic*
2254 *Invertebrates, and Fish*, slight long-term improvements in Chinook salmon and steelhead
2255 metrics, including instream fish survival, are anticipated as compared to the No Action
2256 Alternative under MO4 in Region B, though these improvements would be less than those
2257 anticipated under MO3. These benefits may be noticeable to recreational anglers. Conversely,
2258 there would also be increased entrainment risk for some resident species that could adversely

2259 affect the destination fishery at Lake Roosevelt. Increased stranding is also anticipated for
2260 kokanee and burbot eggs in Lake Roosevelt.

2261 Lake Roosevelt may experience increased shoreline erosion, which could increase total
2262 suspended solids in the water and reduce water clarity. This could adversely affect recreation
2263 on the reservoir. Changes in water surface elevations downstream of Chief Joseph are not
2264 expected to result in measurable effects on wildlife habitat or populations in the Chief Joseph
2265 area. Some changes could reduce pool elevations in Lake Roosevelt upstream of Grand Coulee
2266 Dam, affecting wetland habitats, but these generally are expected to have negligible effects on
2267 recreationists.

2268 **Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams**

2269 MO4 measures for Region C again are similar to MO1 measures for Region C but also include
2270 some additional structural and operational measures. The operational measures are focused on
2271 making improvements and providing flexibility across authorized project purposes while the
2272 structural measures are focused on improving passage conditions for ESA-listed salmonids and
2273 Pacific lamprey.

2274 Similar to MO1, the operation measures include added operating range flexibility at the lower
2275 Snake River for added hydropower generation, and modified timing of the lower Snake Basin
2276 draft for additional cooler water. In addition, MO4 targets *Spill to 125% TDG* and includes
2277 annual *Drawdown to MOP* measures at the Lower Snake River and Columbia River reservoirs.
2278 The structural measures included for projects within Region C include Additional Powerhouse
2279 Surface Passage at Ice Harbor; *Spillway Weir Notch Inserts* at Lower Granite, Lower
2280 Monumental, and Ice Harbor projects; Lower Granite Trap Modifications; adding *Lower Snake*
2281 *Ladder Pumps* to provide cooler water for adult fish ladders at Lower Monumental and Ice
2282 Harbor Dams; and installing entrance weir caps at the four Lower Snake River Projects. In
2283 addition, *Spillway Weir Notch Inserts* would be added to help facilitate downstream passage of
2284 adult salmon.

2285 As described previously, the operational measures would have similar effects to water
2286 elevations and flows over the period of analysis. The structural measures could have localized,
2287 short-term effects to recreation during the anticipated 2-year period when construction occurs
2288 in proximity to the recreation sites close to dams. Effects could include disruption at project
2289 sites, noise, potential traffic congestion, and access limitations during the construction period.

2290 ***Water-Based Recreational Visitation***

2291 Changes in water surface elevations and river flows are expected to be sufficiently minor as not
2292 to affect recreational access and visitation at recreation sites at the five reservoirs and river
2293 reaches in Region C.

2294 **Quality of Recreational Experience**

2295 Changes in the quality of recreational experience are anticipated to be adverse as well as
2296 beneficial in Region C under MO4. As described in Section 3.5, *Aquatic Habitat, Aquatic*
2297 *Invertebrates, and Fish*, instream survival and adult returns of modeled anadromous fish
2298 species would increase slightly under MO4 compared to the No Action Alternative. Increases in
2299 median abundance of Snake River spring-run Chinook would occur in the Middle and South
2300 Forks of the Salmon River (tributaries to the Snake River upstream from Lewiston). Minor to
2301 moderate increases in median abundance of Snake River spring-run Chinook and steelhead
2302 would occur from Lower Granite Dam to the mouth of the Snake River. These benefits may be
2303 noticeable to recreational anglers. However, there may also be increased gas bubble trauma for
2304 bull trout and other resident fish in Region C. Water quality changes that could affect recreation
2305 conditions are expected to be negligible under MO4 in Region C.

2306 In Region C, operational measures under MO4 would result in changing habitat conditions in
2307 some areas along the Snake River that would experience more frequent inundation. Slight
2308 increases in wetland habitat in some locations may have a minor benefit to recreational
2309 activities that are dependent on wetland species, such as wildlife viewing and hunting. No
2310 changes would affect wildlife habitats or populations along the Clearwater River upstream of
2311 the confluence with the Snake River. As such, no effects to recreation are anticipated along the
2312 Clearwater River upstream of the confluence with the Snake River in Region C under MO4.

2313 **Region D – McNary, John Day, The Dalles, and Bonneville Dams**

2314 Similar to Region C, MO4 measures planned for Region D include operational measure and
2315 several structural measures. Structural measures included for Region D projects include
2316 installing *Improved Fish Passage Turbines* at John Day and constructing a surface passage route
2317 for fish through McNary. In addition, similar to Region C (lower Snake River projects), *Spillway*
2318 *Weir Notch Inserts* would be added to help facilitate downstream passage of adult salmon. The
2319 operational measures include operating range flexibility at the John Day project, increasing *Spill*
2320 *to 125% TDG*, annual *Drawdown to MOP* at the lower Snake River and Columbia River
2321 reservoirs, and Additional Powerhouse Surface Passage.

2322 Similar to other regions, structural measures included for Region D projects could have
2323 localized, short-term effects to recreation during the anticipated 2-year period when
2324 construction occurs in proximity to the recreation sites close to dams. Effects could include
2325 disruption at project sites, noise, potential traffic congestion, and access limitations during the
2326 construction period. The operational measures would have similar effects to water elevations
2327 and flows over the 50-year period of analysis.

2328 **Water-Based Recreational Visitation**

2329 Changes in water surface elevations and river flows are expected to be sufficiently minor as not
2330 to affect recreational access and visitation at recreation sites at the four reservoirs and river
2331 reaches in Region D.

2332 **Quality of Recreational Experience**

2333 Changes in the quality of recreational experience are anticipated to be adverse as well as
2334 beneficial in Region D under MO4. As described in Section 3.5, *Aquatic Habitat, Aquatic*
2335 *Invertebrates, and Fish*, slight improvements in Chinook salmon and steelhead metrics,
2336 including instream fish survival, under MO4 are anticipated as compared to the No Action
2337 Alternative in Region D, though these improvements would be less than anticipated under
2338 MO3. Minor increases in median abundance of Snake River spring-run Chinook and steelhead
2339 are anticipated from Bonneville Dam to the mouth of the Snake River. Minor changes in median
2340 abundance of upper Columbia River spring-run Chinook (increase) and steelhead (decrease) are
2341 also anticipated from the mouth of Bonneville Dam to the mouth of the Snake River. However,
2342 drawdown to MOP could reduce sturgeon habitat. It is uncertain whether these benefits would
2343 noticeable to recreational anglers.

2344 Changes in drawdown operations between McNary and John Day Dams could slightly increase
2345 turbidity and phytoplankton, decreasing water clarity and potentially affecting recreational
2346 activities in Region D under MO4. Changes to water quality conditions that could affect
2347 recreation are not expected at other sites in the region.

2348 The vegetation, wetland, and wildlife analyses found that patterns of inundation, seasonal
2349 drying, accretion, and erosion, and effects from these processes on wildlife habitat in the
2350 Columbia River estuary would not substantively change from the No Action Alternative.

2351 **REGIONAL ECONOMIC EFFECTS**

2352 As a result of changes in boat ramp accessibility in a typical year, recreational expenditures
2353 associated with non-local visitation at Lake Koocanusa and Hungry Horse in Region A would
2354 decrease annually by \$2,300 under MO4. Recreational expenditures associated with non-local
2355 visitation at Lake Roosevelt in Region B would decrease annually by \$1.8 million under MO4 in a
2356 typical water year. These changes represent less than 1 percent of non-local recreational
2357 expenditures in the Basin under the No Action Alternative. Because most changes in visitation
2358 would occur along the northern portion of Lake Roosevelt, communities reliant on recreation in
2359 that area—including Northport, Kettle Falls, and Colville—could be adversely affected. No
2360 changes to visitation are anticipated in Region C or D under MO4 relative to the No Action
2361 Alternative.

2362 Overall, the change in non-local visitor regional expenditures in a typical year would result in
2363 approximately 22 fewer jobs, \$780,000 less in labor income, and \$2.2 million less in sales. Most
2364 of the effects would be in Region B, where about 89 percent of affected visitation is non-local. In
2365 a low-water year, decreased expenditures associated with non-local visitation in Region B (Lake
2366 Roosevelt) would lead to 74 fewer jobs, \$2.2 million less in labor income, and \$6.9 million less
2367 sales, a major adverse effect.

2368 As discussed above, the analysis does not detect changes in boat ramp accessibility at Federal-
2369 and state-managed boat ramps at Lake Pend Oreille. However, during low-water years under

2370 MO4 between July and September major adverse impacts to recreation associated with
2371 impaired lake aesthetics (e.g., exposed mud flats) and reduced functionality of fixed docks and
2372 other infrastructure could occur. Because the Lake Pend Oreille area is an important tourism
2373 destination, reductions in visitation would affect the local economy, including the potential to
2374 adversely affect a wide range of businesses that serve visitors.

2375 **OTHER SOCIAL EFFECTS**

2376 There would be beneficial and adverse social effects under MO4. Recreation would continue to
2377 provide other social effects associated with considerable recreational opportunities in the
2378 region under MO4. Continued operation of the system would provide benefits to community
2379 well-being, cohesion, and identity associated with recreational activities. In a typical water year,
2380 changes to recreational visitation due to boat ramp access changes would be minor and
2381 adverse in most locations under MO4, although Lake Roosevelt would experience a 6 percent
2382 decrease in water-based recreation (a moderate effect). In low-water years, Lake Pend Oreille
2383 (Region A) and Lake Roosevelt (Region B) could experience major adverse effects to visitation,
2384 social welfare, and regional economic effects. Communities that are heavily reliant
2385 economically on visitation to affected sites during these low-water periods would be adversely
2386 impacted in the short term. If recreational access is not available at Lake Roosevelt and Lake
2387 Pend Oreille during low-water years and to the extent that visitors are not able to easily access
2388 alternative recreation sites that provide similar benefits, physical, mental, and social health
2389 benefits of individuals and their communities could be diminished, particularly in the short
2390 term.

2391 Anadromous fish species populations would improve under this alternative, which would
2392 benefit recreational experiences in Regions C and D. Restoration of riverine conditions and
2393 increases in anadromous fish species to the lower Snake River has been a long-term objective
2394 of area tribes, who would experience benefits to their ability to utilize the area recreationally
2395 and exercise treaty rights, in addition to other cultural and spiritual benefits. Natural landscapes
2396 and the transition to a natural river state would likely provide many people some social
2397 benefits, as well as educational and scientific research opportunities associated with this unique
2398 area. These benefits would accrue in Regions B, C, and D.

2399 Adverse effects to resident fish species would have adverse effects on fishing experiences in
2400 Region A under MO4, which, in turn, would have adverse effects on the well-being of those
2401 recreationists who value affected fish, particularly area tribes.

2402 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 4**

2403 Overall, MO4 is anticipated to result in minor to moderate adverse effects in a typical water
2404 year, as well as beneficial effects on recreational visitation over the long term. Moderate
2405 adverse effects could occur at Lake Roosevelt during typical water years, while localized major
2406 adverse effects could occur during low-water years from the *McNary Flow Target* measure.
2407 During low-water years, water-based visitation could decrease at Lake Pend Oreille in Region A
2408 due to adverse impacts to lake aesthetics (e.g., exposed mud flats) and reduced functionality of

2409 fixed docks, some city- and county-owned boat ramps, and other infrastructure. Major adverse
2410 impacts to visitation could occur, resulting in decreased social welfare and regional economic
2411 activity during low-water years.

2412 Table 3-265 presents a summary of MO4 effects, including the anticipated changes in average
2413 annual recreational visitation, social welfare, and regional economic effects by region and in
2414 total relative to the No Action Alternative. Across the Basin, total recreational visitation is
2415 anticipated to decrease annually by 0.4 percent (46,000 visits) and associated social welfare
2416 effects by \$0.7 million associated with reductions in access to boat ramps in a typical year. The
2417 change in non-local visitor regional expenditures in a typical year would result in approximately
2418 22 fewer jobs, \$780,000 less in labor income, and \$2.2 million less in sales. In low-water years,
2419 decreased expenditures associated with non-local visitation in Region B would lead to 74 fewer
2420 jobs, \$2.2 million less in labor income, and \$6.9 million less in sales. The largest adverse effects
2421 are anticipated at Lake Roosevelt in Region B in a low-water year and at Lake Pend Oreille in
2422 Region A in a low-water year. Some increased shoreline erosion may also occur in Region B. For
2423 a comparison of anticipated social welfare and regional economic effects across alternatives
2424 refer to Table 41 in Appendix M.

2425 Resident fish entrainment would increase in Region A, which could adversely affect the quality
2426 of fishing experiences there. However, anadromous fish species would benefit under this
2427 alternative, which could benefit recreationists in Regions B, C, and D. There would be negligible
2428 to minor adverse effects to the quality of hunting, wildlife viewing, swimming, and water sports
2429 at river recreation sites in the region under MO4.

2430 During low water level years under MO4, water-based visitation may decrease at Lake Pend
2431 Oreille in Region A due to reduced functionality of fixed docks and reduced usability of city- and
2432 county-owned boat ramps, marinas, and municipal facilities. Over time, visitors may adjust their
2433 behavior to adapt to changes in accessibility and site quality, such as using different sites on the
2434 system. These long-term adaptations could reduce effects of changes in visitation. At Lake Pend
2435 Oreille during low-water years, active management, such as boat dock extensions and possibly
2436 dredging would likely be needed to reduce the effects of low water.

2437 **Table 3-265. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 4 Relative to the No Action**
2438 **Alternative**

Region	Social Welfare Effects	Regional Economic Effects (2019 dollars)	Other Social Effects
Region A	<p>A reduction of less than 100 water-based recreational visits (0.1 percent of regional water-based visitation) would occur at Lake Koochanusa and Hungry Horse Reservoirs in a typical year associated with boat ramp access. Changes would be similar under low- and high-water-level years. Social welfare changes would be negligible associated with changes in boat ramp access. During low water level years, water-based visitation could decrease at Lake Pend Oreille due to adverse impacts to lake aesthetics and reduced functionality of fixed docks, some city- and county-owned boat ramps, and other infrastructure. During low-water years, major adverse impacts to social welfare could occur.</p> <p>Adverse effects to resident fish species would have adverse effects on recreational fishing experiences. Minor effects associated with increases in invasive species could adversely affect the quality of fishing, hunting, wildlife viewing, swimming, and water sports at recreation sites in the region.</p>	<p>Expenditures associated with non-local recreational visits would decrease by \$2,300 across the region associated with boat ramp access (less than 0.01 percent). Regional economic effects of this change in expenditures would be negligible. If recreationists reduce recreation trips to this region due to declines in recreation experiences, additional effects could occur. Effects to water levels at Lake Pend Oreille in low water years could have a major adverse effect on tourism and regional spending.</p>	<p>During low-water years only, social effects could occur to residents and communities at Lake Pend Oreille from decreased visitation and tourism activity.</p> <p>Adverse effects to resident fish species would have adverse effects on fishing experiences and the well-being of recreationists who value affected resident fish, particularly area tribes.</p>

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Chapter 3, Affected Environment and Environmental Consequences*

Region	Social Welfare Effects	Regional Economic Effects (2019 dollars)	Other Social Effects
Region B	A reduction of approximately 45,000 water-based visits at Lake Roosevelt (5.9 percent of water-based visitation at the site) would occur in a typical water year associated with boat ramp access, a moderate adverse effect. Annual social welfare benefits would decrease by approximately \$684,000 in a typical water year, associated with changes in boat ramp access. Visitation would decrease by about 6 percent in high-water-level years and decrease by around 24 percent in low- water years (about 175,000 visits), a major adverse effect, resulting in an average annual decrease of \$2.6 million in social welfare. Changes in the quality of recreational experience are anticipated to be adverse as well as beneficial. In-river survival and abundance of wild salmon would increase, which would benefit river as well as reservoir recreationists in areas accessible to wild salmon. However, increased entrainment risk for some resident species (bull trout, kokanee, rainbow trout, burbot) could adversely affect the destination fishery at Lake Roosevelt.	Expenditures associated with non-local recreational visits would decrease by \$1.8 million across the region (2.3 percent compared to NAA) associated with changes in boat ramp access. Regional economic effects of this change in expenditures would be minor to moderate in typical water years. In low-water years, decreased expenditures associated with non-local visitation would lead to 74 fewer jobs, \$2.2 million less in labor income, and \$6.9 million less in sales; localized major adverse effects could occur at Lake Roosevelt. To the extent that increases in anadromous fish populations draw visitors to the region, regional economic expenditures and effects would increase.	Adverse social effects could occur for residents and communities at Lake Roosevelt from decreased visitation and tourism activity, primarily during low-water years. The Spokane Tribe and the Confederated Tribes of the Colville Reservation could experience adverse effects from change in water-based recreation visitation, and a related decrease in tourism activity and expenditures. Likewise decreased well-being of water-based recreation visitors could occur due to the sizable reduction in recreation days during a low-water year. However, slight improvements in anadromous fish populations would contribute to improved well-being for recreationists who value these populations, while resident species and related recreational fisheries could be adversely affected.
Region C	No changes to reservoir visitation related to changes in boat ramp access. Changes in the quality of recreational experience are anticipated to be adverse as well as beneficial. In-river survival and abundance of wild salmon would increase, which would benefit river recreationists. However, there may also be increased gas bubble trauma for bull trout and other resident fish.	No measurable changes in visitor expenditures or regional effects associated with boat ramp access. To the extent that increases in anadromous fish populations draw visitors to the region, regional economic expenditures and effects would increase.	No change from NAA for boat ramp access. Improvements in anadromous fish populations would contribute to improved well-being for recreationists who value these populations, while resident species and related recreational fisheries could be negatively affected.
Region D	No changes to reservoir visitation related to changes in boat ramp access. Changes in the quality of recreational experience are anticipated to be adverse as well as beneficial. In-river survival and abundance of wild salmon would increase, which would benefit river recreationists. Minor improvements in wildlife viewing may occur. However, drawdown to MOP could reduce sturgeon habitat.	No measurable changes in visitor expenditures or regional effects associated with boat ramp access. To the extent that increases in anadromous fish populations draw visitors to the region, regional economic expenditures and effects would increase.	No change from NAA for boat ramp access. Slight improvement in well-being for recreationists who value potential increase in anadromous fish populations and opportunities for wildlife viewing, however also potential for slight decrease in well-being for recreationists who value sturgeon.

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Region	Social Welfare Effects	Regional Economic Effects (2019 dollars)	Other Social Effects
Total	<p>Minor to moderate adverse effects to reservoir visitation associated with boat ramp access (46,000 fewer visits, representing approximately 0.3 percent of total visitation) in a typical year, with annual social welfare losses of approximately \$684,000 annually. Most changes occur in Region B, where 89 percent of visitation is non-local. In low-water years, major adverse social welfare effects could occur at Lake Roosevelt—a 24 percent decrease in water-based visitation (about 175,000 visits), resulting in an average annual decrease of \$2.6 million in social welfare compared to NAA. In addition, major adverse effects could occur in low-water years at Lake Pend Oreille due to accessibility impacts to multiple facilities and infrastructure.</p> <p>Changes in the quality of recreational experience are anticipated to be adverse as well as beneficial. In-river survival and abundance of wild salmon would increase, which would benefit river recreationists. Minor improvements in wildlife viewing may occur. However, adverse effects to resident fish may also occur.</p>	<p>Expenditures associated with non-local recreational visits would decrease by \$1.8 million across the region (a change of less than 1 percent from No Action) associated with changes in boat ramp access in a typical year. Economic effects of this change in expenditures would be 22 fewer jobs, \$780,000 less in labor income, and \$2.2 million less in sales.</p> <p>In low-water years, localized major adverse regional economic effects could occur at Lake Roosevelt—a 24 percent decrease in water-based visitation, leading to 74 fewer jobs, \$2.2 million less in labor income, and \$6.9 million less in sales in Region B. In addition, major adverse effects to regional economic conditions could occur in low-water years at Lake Pend Oreille due to accessibility impacts to multiple facilities and infrastructure.</p> <p>To the extent that increases in anadromous fish populations draw visitors to the region, regional economic expenditures and effects would increase.</p>	<p>Adverse social effects could occur for residents and communities at Lake Roosevelt and Lake Pend Oreille from decreased visitation and tourism activity during low water years.</p> <p>Generally, improvements in anadromous fish populations would contribute to improved well-being for recreationists in Regions C and D.</p> <p>Some adverse effects associated with decreases in resident fish populations in Region A.</p>

2440 **3.11.3.7 Tribal Interests**

2441 The presence of dams and system operations have had long-term adverse effects on the
2442 recreational opportunities for area tribes, particularly for fishing and hunting. Section 3.16,
2443 *Cultural Resources*, and Section 3.17, *Indian Trust Assets, Tribal Perspectives, and Tribal*
2444 *Interests*, provide additional information about ongoing effects as well unique effects of MOs
2445 on tribal recreational activities, subsistence activities, and cultural practices.

2446 The fish resources of the Columbia River Basin are caught in commercial, recreational, and
2447 tribal ceremonial and subsistence fisheries both within the Basin and in the ocean off the coasts
2448 of Washington, Oregon, California, British Columbia, and Alaska. Fish are a natural resource of
2449 invaluable importance to the tribes of the region, and some tribes reserved the right to catch
2450 these fish in treaties signed with the United States. The Federal government has a trust
2451 responsibility to preserve the treaty-reserved rights of those tribes. The Fisheries and Passive
2452 Use section of this EIS (Section 3.15) discusses ceremonial and subsistence fishing activities, as
2453 well as commercial fishing activities in more detail.

2454 At Lake Roosevelt, the Spokane Tribe of Indians and the Confederated Tribes of the Colville
2455 Reservation manage recreation in those parts of the Lake Roosevelt National Recreation Area
2456 that fall within their respective reservation boundaries. This tribal management of recreation is
2457 one of the outcomes of the Lake Roosevelt Cooperative Management Agreement of 1990.
2458 Other tribes also manage recreation areas, provide tours, and other services that are
2459 dependent on natural conditions and resources in the Basin.

2460 Adverse effects to resident fish species would have adverse effects on fishing experiences in
2461 Region A under MO4, which, in turn, would have adverse effects on the well-being of those
2462 recreationists who value affected fish, particularly area tribes.

2463 Anadromous fish species populations would improve under MO1, MO3, and MO4 in the lower
2464 Snake River, which has been a long-term objective of area tribes. Under these MOs tribes that
2465 use that area would experience benefits in their ability to recreate and exercise treaty rights, as
2466 well as experience other cultural and spiritual benefits. The largest benefits to these fish would
2467 accrue under MO3 and MO4. However, tribes in other areas may not experience these benefits.
2468 In particular, MOs that would adversely affect resident fish in the upper Basin, such as MO2 and
2469 MO4, may have adverse effects on recreational resources for tribes in those areas.

2470 **3.12 WATER SUPPLY**

2471 **3.12.1 Introduction and Background**

2472 The mainstem Columbia River, lower Snake River, Clearwater River, Kootenai River, Pend
2473 Oreille River, and Flathead River (the study rivers) provide water for millions of people and
2474 irrigated agriculture in Oregon, Washington, Idaho, and Montana. Water is pumped from the
2475 reservoirs of 9 of the 14 Federal Projects: Grand Coulee, Lower Granite, Lower Monumental,
2476 Little Goose, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. Annually, about 7 Maf
2477 of water is supplied for irrigation, drinking water, and other municipal and industrial (M&I)
2478 needs (USGS 2017).

2479 This section describes both the physical and socioeconomic existing conditions relating to water
2480 supply. Water supply is defined as the water used for the irrigation of crops as well as municipal
2481 and industrial uses. It also describes the environmental consequences resulting from the
2482 alternatives presented in Chapter 2. The physical existing condition description quantifies the
2483 irrigated lands and M&I needs associated with potentially affected areas. The socioeconomic
2484 existing condition description outlines social and economic conditions that could potentially be
2485 affected by changes to the physical existing condition for water supply.

2486 The purpose of the water supply analysis is to evaluate the effects of operational and structural
2487 measure changes on current water supply obligations as described in the No Action Alternative.
2488 This should not be confused with the future water supply measures that are intended to
2489 explore the effect of diverting additional water on the flow and stage in the rivers.

2490 About 1,393,000¹ acres are irrigated with water diverted within the study area. Growers in the
2491 potentially affected areas depend on irrigation to produce a wide variety of crops, including
2492 alfalfa, small grains, vegetables, fruits, and wine grapes.

2493 About 5 percent² of the Columbia River Basin's water is diverted for agriculture. Irrigation water
2494 is diverted directly from the rivers and from the reservoirs behind storage and run-of-river
2495 projects, and is also pumped from groundwater wells. Diversions can vary from year to year and
2496 from month to month in response to varying weather and hydrologic conditions. A portion of
2497 the diverted water can travel back into the rivers and is known as irrigation return flow.

2498 Though not all of these areas would be affected by potential changes to operations and
2499 maintenance of the CRS, irrigation throughout the projects is described here for context.

¹ Calculated using place-of-use polygons from the individual states for acres irrigated with water from the Columbia, lower Snake, Clearwater, Kootenai, Pend Oreille, and Flathead Rivers. Includes 720,000 acres in the Columbia Basin Project.

² Calculated using 30-year average from 1981 to 2010 inflow to The Dalles of 133 Maf (NWRFC 2018) and 7.1 MAF of diversion for entire study area (Bonneville 2011b).

2500 **3.12.1.1 Federal Irrigation Projects**

2501 Grand Coulee and Hungry Horse, operated by Reclamation, are the only projects of the 14 that
2502 are authorized to store water for irrigation. Grand Coulee stores water for the Columbia Basin
2503 Project; Hungry Horse does not currently store water for irrigation despite its authorization to
2504 do so.

2505 At Grand Coulee, the water is pumped up approximately 300 vertical feet from behind the dam
2506 at Lake Roosevelt to a feeder canal that delivers water to Banks Lake, where it is stored and
2507 eventually released and distributed by canal to irrigators within the Columbia Basin Project. The
2508 Columbia Basin Project has water rights and previous NEPA compliance to deliver 3.248 Maf³ of
2509 irrigation water to 720,000 acres⁴ in Grant, Adams, Walla Walla, and Franklin Counties. Some of
2510 these acres have not yet been developed, so past measured deliveries are smaller than this
2511 volume. The Burbank pumps in the McNary Reservoir also supply about 23,000 acre-feet of
2512 water to the Columbia Basin Project.

2513 The Chief Joseph Project, operated by Reclamation, pumps water from the Columbia River
2514 below the Corps' Chief Joseph Dam. The project was authorized over many years (versus all at
2515 once, which is more common) with authorizations totaling 33,050 acres (some of these acres
2516 have been transferred outside of the Federal project). Currently, 97,920⁵ acre-feet of water is
2517 delivered to 28,800 Federal project acres.⁶

2518 **3.12.1.2 Non-Federal Irrigation Withdrawals**

2519 Non-Federal parties divert water for irrigation at many locations within the study area.
2520 Extensive areas of irrigated agriculture have developed near the reservoirs behind the four
2521 lower Columbia River dams (Bonneville, John Day, The Dalles, and McNary) and the reservoir
2522 behind Ice Harbor Dam on the lower Snake River. The projects are authorized for irrigation, but
2523 no water is stored for irrigation and none of the projects have specific features to
2524 accommodate irrigation, and there are no irrigation contracts with the Federal government.
2525 They are run-of-river projects that maintain elevated reservoir levels primarily for power
2526 generation and navigation. The exception is John Day, which maintains a slightly higher
2527 reservoir elevation than is needed for navigation to ensure that irrigation pumps can operate.
2528 Both small pumps and large-scale pumping plants that serve multiple users withdraw water
2529 from the reservoirs for pumping to fields. This water is diverted under natural or live flow rights
2530 issued by the states.

³ There are water rights for 3.318 Maf, but 70,000 acre-feet is used for M&I.

⁴ Includes acres for Odessa (Reclamation 2013) and Lake Roosevelt Incremental Storage Agreement (Reclamation 2009).

⁵ 28,800 acres multiplied by the current delivery rate of 3.4 acre-feet per acre.

⁶ Distinction is made between federally owned acres for this project because it was part of the determination of the remaining undeveloped acres from the original authorization.

2531 **3.12.1.3 Municipal and Industrial Water Supply**

2532 Use of water from the study area to meet M&I water supply needs is approximately 0.5
2533 percent⁷ of the annual flow in the Columbia River Basin, which is about one tenth of the
2534 amount used for irrigation. Some cities and industries divert water from the river system, but
2535 these diversions are small to the point of being unmeasurable when compared to the total flow
2536 in the system. Most of this water is diverted under flow rights issued by the states.

2537 The largest M&I water withdrawals from the lower Snake and lower Columbia Rivers are
2538 concentrated on or near the Lower Granite and McNary Reservoirs. Municipal water users
2539 withdrawing directly from the McNary Reservoir include the cities of Hermiston, Richland,
2540 Kennewick, and Pasco. Industrial water users, including the Port of Umatilla, also have intakes
2541 nearby. The City of Lewiston and the Potlatch Corporation have water supply intakes on the
2542 Clearwater River above Lower Granite Dam. The Columbia Basin Project has water rights to
2543 deliver 70,000 acre-feet of M&I water to its customers.

2544 **3.12.1.4 Area of Analysis**

2545 The scope of this study is limited to the regions in the study area where operational or
2546 structural changes in the alternatives have the potential to affect the ability to supply water for
2547 agriculture and M&I purposes. Only the regions and associated lands where the analysis
2548 showed a limitation in the ability to deliver water were further analyzed for socioeconomic
2549 effects.

2550 The H&H models assume that the current diversion volume⁸ of water for irrigation and M&I is
2551 delivered in all years and for all alternatives. As a result, the flow in the river in all years and for
2552 all alternatives reflects what would occur when all current irrigation and M&I demands are met
2553 and would not appear to be affected. As long as water surface elevations do not change
2554 substantially, it is assumed that these deliveries can be made with current infrastructure.
2555 However, changes in reservoir elevation such that water could not physically be diverted could
2556 affect the ability to deliver water. In addition, reservoir elevations could also affect efficiency in
2557 terms of the energy required to pump water both from surface and groundwater pumps.

2558 Both the modeling analysis and the measure descriptions indicated which regions would have
2559 effects to reservoir elevations such that water could no longer be delivered.

2560 **FUTURE WATER SUPPLY MEASURES**

2561 Socioeconomic effects were not evaluated for increased pumping from Grand Coulee or
2562 increased water supply from the Hungry Horse or Chief Joseph Projects for the future water
2563 supply measures. The details of how and where this water would be used is subject to an as-yet

⁷ Calculated using 650,000 acre-feet (USGS 2017) from the counties using M&I water in the study area and 133 Maf from NWRFC (2018).

⁸ This includes all diversions for irrigation and M&I including both Federal and non-Federal obligations.

2564 undefined future Federal action and additional NEPA analysis would be needed prior to taking
2565 any such action. Additional information is provided in Appendix N, *Water Supply*.

2566 The effects of delivering this water on flow and stage are described in sections addressing
2567 resources that are affected by changes to flow and stage such as H&H, Water Quality, and Fish.
2568 Any effects to the ability to deliver water supply are the combined effects of the measures in
2569 each MO, which may include the future water supply measures.

2570 **3.12.2 Affected Environment**

2571 ***3.12.2.1 Physical Water Supply***

2572 This section describes the physical aspects of the existing conditions for water supply, including
2573 the quantification of water needed for irrigation, municipal, and industrial supply; the locations
2574 where water is diverted from surface water and from groundwater wells within 1 mile of the
2575 river; and the lands that use that water for irrigation.

2576 Only the projects that may be affected in each region are described. In some cases, there is not
2577 enough data to quantify the effects to each region, particularly with respect to pump operating
2578 elevations. Qualitative statements are provided in these instances.

2579 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

2580 In Region A, there are diverters of irrigation and M&I water throughout the region, particularly
2581 in the river reaches below the dams (Table 3-266). Though there are many diversion points,
2582 these are primarily small private diverters that individually do not use large quantities of water.
2583 These surface water pumps could be impacted if the flow in the river decreases and reduces the
2584 stage to the point where the pumps either cannot operate or operate less efficiently. There is
2585 limited data available about these pumps, so qualitative assessments are made about possible
2586 effects.

2587 In addition, there are groundwater wells within 1 mile of the rivers (Table 3-266). Given the
2588 likely small change in river stage due to changes in outflow, it is anticipated that these will not
2589 be affected in this Region.

2590 **Table 3-266. Possible Affected Groundwater Wells and Surface Water Pumps in Region A**

Project	M&I Wells – Groundwater Diversions	M&I Pumps – Surface Water Diversions	Irrigation Wells – Groundwater Diversions	Irrigation Pumps – Surface Water Diversions
Below Libby	699	35	104	37
Below Hungry Horse	3,076	767	824	328
Lake Pend Oreille	174	69	83	93

2591 **Irrigation**

2592 In Region A, approximately 675,000 acre-feet of water is diverted on an average annual basis
2593 for irrigation, with a portion of that water returning to the river as return flows (Bonneville
2594 2011b). This water is supplied primarily from the rivers below the projects and is regulated by
2595 state water rights law.

2596 **Municipal and Industrial**

2597 In the counties surrounding Region A, approximately 31,000 acre-feet of water is diverted for
2598 M&I purposes from both surface and groundwater (USGS 2018a; Table 3-267).

2599 **Table 3-267. Summary of Municipal and Industrial Use by County for Surface and**
2600 **Groundwater in Counties that Border the River Reaches below the Columbia River System**
2601 **Projects in Region A**

County ^{1/}	State	Surface Water (acre-feet)	Groundwater (acre-feet)
Boundary County	ID	1,000	300
Lincoln County	MT	1,800	1,800
Lake County	MT	400	3,600
Flathead County	MT	2,700	13,700
Bonner County	ID	2,700	3,000
Total	–	8,600	22,400

2602 1/ Kootenai County was not included because most of the M&I use in that county was near Coeur d’Alene, which is
2603 not within the study area.

2604 Source: USGS 2018a

2605 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

2606 In Region B, the largest diversion of water occurs from Lake Roosevelt at the John W. Keys
2607 Pumping Plant, which pumps up to 3.318 Maf annually for irrigation and M&I on the Columbia
2608 Basin Project. In addition, there are small pumps that divert for irrigation and M&I purposes
2609 from Lake Roosevelt (Table 3-268). These surface water pumps vary in capacity, location, and
2610 water surface elevation requirement. Specific data on individual pump elevations is not readily
2611 available. That being said, the pump operating elevations can be inferred from historical

2612 reservoir elevations by assuming the pumps could have operated for their designated purpose
2613 under historical reservoir elevations.

2614 In addition, there are groundwater wells within 1 mile of these reservoirs that pump for
2615 irrigation and M&I purposes. These wells have the potential for groundwater connectivity with
2616 the water in the reservoirs, i.e., changes in water surface elevation in the reservoirs may
2617 translate to changes in water surface elevation in the wells. However, there is not enough data
2618 to determine which of the wells are hydraulically connected and therefore the extent of the
2619 possible effects from changing reservoir elevations.

2620 **Table 3-268. Possible Affected Groundwater Wells and Surface Water Pumps in Region B**

Project	M&I Wells – Groundwater Diversions	M&I Pumps – Surface Water Diversions	Irrigation Wells – Groundwater Diversions	Irrigation Pumps – Surface Water Diversions
Grand Coulee	270	84	165	114

2621 **Irrigation**

2622 In Region B, in addition to the 3.318 Maf delivered to the Columbia Basin Project, up to 35,500
2623 acre-feet of water is delivered for irrigation annually, with a portion of the water returning to
2624 the river as return flows (Bonneville 2011b). That water is used to grow a variety of crops,
2625 including fruit, small grains, hay, grapes, and irrigated vegetables.

2626 **Municipal and Industrial**

2627 In the counties surrounding the reaches in Region D that could be impacted by changes to
2628 operations and maintenance, about 16,860 acre-feet are diverted for M&I purposes (USGS
2629 2017; Table 3-269). The M&I users in this region are largely small private users with individually
2630 owned pumps.

2631 **Table 3-269. Summary of Municipal and Industrial Use by County for Surface and**
2632 **Groundwater in Counties that Border Lake Roosevelt in Region B**

County	State	Surface Water (acre-feet)	Groundwater (acre-feet)
Lincoln County	WA	–	3,100
Ferry County	WA	80	1,500
Stevens County	WA	80	10,600
Grant County	WA	600	900
Total	–	760	16,100

2633 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
2634 **HARBOR DAMS**

2635 At Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Projects, numerous
2636 irrigation and M&I pumps are used for surface water diversions from the various reservoirs

2637 (Table 3-270). These pumps vary in capacity, location, and water surface elevation
 2638 requirements. In addition, there are groundwater wells within 1 mile of these reservoirs that
 2639 have the potential to have groundwater connectivity with the water in the reservoirs. If these
 2640 reservoir elevations were to change, there is potential for the groundwater table to change.
 2641 The data in Table 3-270 summarizes the number of pumps and wells within 1 mile of the lower
 2642 Snake projects. Specific data on individual pump elevations is not readily available. That being
 2643 said, average pump elevations, and thus operational requirements, can be inferred by referring
 2644 to the minimum operating pool (MOP) elevations for individual reservoirs as listed in
 2645 Table 3-271. In addition, specific information about the connectivity of the groundwater wells
 2646 with the reservoirs is not available, so it is possible that some of these wells will not be
 2647 affected.

2648 **Table 3-270. Possible Affected Groundwater Wells and Surface Water Pumps in Region C**

Project	M&I Wells – Groundwater Diversions	M&I Pumps – Surface Water Diversions	Irrigation Wells – Groundwater Diversions	Irrigation Pumps – Surface Water Diversions
Lower Granite	71	11	55	30
Little Goose	18	0	15	3
Lower Monumental	17	2	17	9
Ice Harbor	28	3	45	25

2649 Source: Reclamation 2019

2650 **Table 3-271. Minimum Operating Pool Elevations in Region C**

Project	MOP Elevation (ft NGVD29)	MOP Elevation (ft NAVD88)
Lower Granite	733	736.4
Little Goose	633	636.2
Lower Monumental	537	540.3
Ice Harbor	437	440.4

2651 **Irrigation**

2652 In Region C, an average of approximately 316,000 acre-feet of water is diverted annually for
 2653 irrigation, with a portion of that water returning to the river as return flows (Bonneville 2011b).
 2654 The water is pumped from the reservoirs behind Lower Granite, Lower Monumental, Little
 2655 Goose, and Ice Harbor dams. These projects are run-of-river dams that are operated for the
 2656 primary purposes of hydropower generation and navigation. Non-Federal water users
 2657 advantageously use the already-elevated reservoirs to pump water for irrigation. That water is
 2658 used to grow a variety of crops and livestock, including fruit trees, grapes, potatoes, corn, and
 2659 grains.

2660 Cattle watering corridors provide access across government property for cattle to water from
 2661 the lower Snake River projects. These corridors are fenced off down to the riverbank. Rights to
 2662 establish corridors were established as reserved cattle watering easements in the acquisition
 2663 deeds. There are 45 instances of reserves that allow for one or more corridors to be established

2664 for cattle water purposes. Fifteen of these reserves are located at Lower Monumental, 15 are
2665 located at Little Goose, 11 at Ice Harbor, and 4 at Lower Granite (Corps 2019).

2666 **Municipal and Industrial**

2667 In the counties surrounding Region C, approximately 21,330 acre-feet of water is diverted for
2668 M&I purposes (USGS 2018a; Table 3-272). The largest M&I water withdrawals from the study
2669 area are concentrated on or near the Lower Granite Reservoir, though there are other small
2670 private users along the river throughout the region.

2671 **Table 3-272. Summary of M&I Use by County for Surface and Groundwater in Counties that**
2672 **Border the Lower Snake River in Region C**

County ^{1/}	State	Surface Water (acre-feet)	Groundwater (acre-feet)
Asotin County	WA	30	6,200
Nez Perce County	ID	9,200	5,100
Garfield County	WA	–	800
Total	--	9,230	12,100

2673 1/ Does not include: Columbia County, Whitman County, or Franklin County, Washington. The majority of M&I
2674 activity in these counties appears to be on tributaries outside the scope of this study area. Removed Walla Walla
2675 County, Washington, because most of the M&I activity for this county was in the city of Walla Walla, which is
2676 outside of the study area.

2677 Source: USGS 2018a

2678 The primary users of the Lower Granite Reservoir are the Cities of Lewiston and Clarkston and
2679 the Potlatch Corporation. The City of Lewiston supplies drinking and irrigation water partly from
2680 the Clearwater and partly from six groundwater wells (Lewiston 2018). Asotin County PUD
2681 supplies water to the City of Clarkston from groundwater wells (Asotin 2018).

2682 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

2683 The data in Table 3-273 summarizes the number of pumps in the river and groundwater wells
2684 within 1 mile of the McNary and John Day Reservoirs. As in Region C, the pumps vary in
2685 capacity, location, and water surface elevation requirements. In addition, the groundwater
2686 wells within 1 mile of these reservoirs have the potential for changes in the shallow aquifer as
2687 elevations in the reservoir change, as they could be hydraulically connected to the reservoir; it
2688 is possible that some are not hydraulically connected but data is not available for verification.

2689 **Table 3-273. Number of Irrigation and Municipal and Industrial Diversions (Pumps and Wells)**
2690 **in John Day Reservoir**

Project	M&I Wells – Groundwater Diversions	M&I Pumps – Surface Water Diversions	Irrigation Wells – Groundwater Diversions	Irrigation Pumps – Surface Water Diversions
McNary	1,081	70	936	83
John Day	96	14	118	55

2691 **Irrigation**

2692 In Region D, an average of approximately 530,000 acre-feet of water is diverted annually for
 2693 irrigation, with a portion of water returning to the river as return flows (Bonnevill 2011b). The
 2694 John Day Project is operated to a minimum irrigation pool of 262.5 feet NGVD29 (265.7 feet
 2695 NAVD88) elevation to allow non-Federal water users to pump water for irrigation. That water is
 2696 used to grow a variety of crops, including potatoes, fruit trees, grapes, corn, and grains.

2697 **Municipal and Industrial**

2698 In the counties surrounding Region D that could be impacted by changes to operations and
 2699 maintenance, about 34,400 acre-feet are diverted for M&I purposes (USGS 2017; Table 3-274).
 2700 Cities surrounding the McNary and John Day Reservoirs get their drinking water from both
 2701 surface and groundwater sources. There are also many pumps and wells that list domestic
 2702 water as a use, indicating that there are private users who may be using water from the river,
 2703 and/or shallow groundwater, for drinking water.

2704 **Table 3-274. Summary of Municipal and Industrial Use by County for Surface and**
 2705 **Groundwater in Counties that Border the Lower Columbia River in Region D**

County ^{1/}	State	Surface Water (acre-feet)	Groundwater (acre-feet)
Benton County	WA	14,500	2,900
Klickitat County	WA	2,400	4,600
Morrow County	OR	5,000	5,000
Umatilla County	OR	5,000	1,500
Total	–	21,900	12,500

2706 1/ Walla Walla County is excluded because most of the drinking water is likely in the city of Walla Walla. The Port
 2707 of Umatilla and the City of Umatilla are the only entities used for Umatilla County (data from Oregon Water
 2708 Resources Department water use reports).

2709 Source: USGS 2017

2710 **3.12.2.2 Socioeconomic Water Supply**

2711 The water supply socioeconomic analysis area is described below for Regions A, B, C, and D. In
 2712 some instances, the socioeconomic analysis regions (Regions A through D) were further
 2713 delineated into subsets or reaches for describing water supply–related socioeconomic effects.
 2714 These reaches are based on where the physical water supply effects occur. These analysis areas
 2715 are specifically used to describe the regional economic effects and the other social effects. The
 2716 social welfare effects are described from a national standpoint; however, data to measure
 2717 these effects is specific to these reaches. Table 3-275 summarizes how the water supply
 2718 socioeconomic analysis areas are organized.

2719 **Table 3-275. Water Supply Socioeconomic Analysis Regions and Analysis Areas**

Region Name	Reach Name	County	State	County and State Included in the Socioeconomic Analysis Region	Modeled Socioeconomic Analysis Areas Name
Region A	Libby, Hungry Horse, and Albeni Falls	Bonner	ID	Bonner, ID	Bonner
Region B	Grand Coulee	Adams Franklin Grant Lincoln	WA WA WA WA	Adams, WA Franklin, WA Grant, WA Lincoln, WA	Columbia Basin Project
Region C	Lower Granite	Nez Perce Asotin	ID WA	Nez Perce, ID Garfield, WA	Lower Granite and Little Goose
	Little Goose	Garfield Whitman	WA WA	Whitman, WA Asotin, WA	
	Ice Harbor	Franklin Walla Walla	WA WA	Columbia, WA Franklin, WA	Ice Harbor and Lower Monumental
	Lower Monumental	Columbia Franklin Walla Walla	WA WA WA	Walla Walla, WA	
Region D	John Day	Benton Klickitat Morrow Umatilla	WA WA OR OR	Benton, WA Klickitat, WA Morrow, OR Umatilla, OR	John Day

2720 Economic activity is commonly measured through employment, labor income, and industry
2721 output (sales). Employment measures the number of jobs (full time and part time) related to
2722 each of the industry sectors of the regional economy. Labor income is the sum of employee
2723 compensation and proprietor income. Industry output (sales) represent the value of goods and
2724 services produced by businesses within a sector of the economy. These measures are described
2725 below for each area that was modeled for the water supply socioeconomic analysis. More detail
2726 is found in Appendix N, *Water Supply*.

2727 The data used to derive these measurements was obtained from IMPLAN (IMpact analysis for
2728 PLANning). This analysis used 2017 IMPLAN data for the counties which encompass the analysis
2729 areas. IMPLAN data files are compiled from a wide variety of sources including the U.S. Bureau
2730 of Economic Analysis, the U.S. Bureau of Labor, and U.S. Census.

2731 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

2732 The water supply socioeconomic analysis is comprised of Idaho’s Bonner County. Potential
2733 water supply impacts may impact M&I users within this area.

2734 Employment in the Bonner County area is approximately 22,000 jobs (full time and part time).
2735 The largest number of jobs is generated by activities related to the retail trade sector
2736 (12.47 percent of total regional employment). The government sector ranks second in terms of
2737 overall number of jobs in the analysis area, with 10.77 percent of total regional employment.

2738 Labor income in Bonner County is estimated at \$800,280. The manufacturing and government
2739 sectors are the largest contributors to labor income (17.87 percent and 17.09 percent,
2740 respectively).

2741 Output (sales) equals \$3,235,100. The manufacturing industry leads the Bonner County in
2742 output or sales at 29.36 percent of the total output (sales). The real estate sector ranks second
2743 at 11.92 percent.

2744 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

2745 The water supply socioeconomic analysis encompasses Adams, Franklin, Grant, and Lincoln
2746 Counties in the state of Washington. Reclamation’s Columbia Basin Project is located within this
2747 region.

2748 Employment in the Columbia Basin Project area (four counties) is approximately 104,700 jobs (full
2749 time and part time). Activities related to the agricultural sector generate the largest number of jobs,
2750 with 21.56 percent of total regional employment. The government sector ranks second in terms of
2751 overall number of jobs in the Columbia Basin Project area, with 16.0 percent of total regional
2752 employment. Employment within the agricultural sector is primarily related to fruit farming (37.42
2753 percent), support activities for agriculture (31.26 percent), and vegetable farming (15.38 percent).

2754 Labor income in this Columbia Basin Project area is estimated at \$5,806,460. The agricultural and
2755 government sectors make the largest contribution to labor income (27.01 percent and 19.19
2756 percent, respectively). The manufacturing sector ranks third, making up 10.33 percent of total labor
2757 income in the Columbia Basin Project area.

2758 Output (sales) equals \$17,645,040. The manufacturing industry leads the Columbia Basin Project
2759 area in output or sales at 24.80 percent of the total output (sales). The agricultural sector ranks
2760 second at 20.07 percent.

2761 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE** 2762 **HARBOR DAMS**

2763 Water supply socioeconomic effects for Region C were modeled in two different areas. The Ice
2764 Harbor and Lower Monumental area is composed of Washington’s Columbia, Franklin, and
2765 Walla Walla Counties. The Lower Granite and Little Goose area is made up of Idaho’s Nez Perce
2766 County and Washington’s Asotin, Garfield, and Whitman Counties.

2767 **Ice Harbor and Lower Monumental**

2768 Employment in the Ice Harbor and Lower Monumental analysis area is approximately 81,500 jobs
2769 (full time and part time). The government sector’s activities generate the largest number of jobs
2770 (15.26 percent of total regional employment). The agricultural sector ranks second in terms of
2771 overall number of jobs in the analysis area, with 14.7 percent of total regional employment. Health
2772 and social services related employment ranks third, making up 10.13 percent of total regional
2773 employment. Employment within the agricultural sector is primarily related to fruit farming (36.23

2774 percent), vegetable farming (16.52 percent), and all other crop farming (which include grapes; 11.84
2775 percent).

2776 Labor income in this area is estimated at \$4,270,650. The government and agricultural sectors make
2777 the largest contribution to labor income within the area (20.4 percent and 17.9 percent,
2778 respectively). The manufacturing sector ranks third, making up 10.72 percent of total labor income
2779 in the area.

2780 Output (sales) equals \$12,964, 430. The manufacturing industry leads the area in output (sales) at
2781 26.64 percent of the total. The agricultural sector ranks second at 11.51 percent.

2782 **Lower Granite and Little Goose**

2783 Employment in the Lower Granite and Little Goose area is approximately 63,000 jobs (full time and
2784 part time). Activities related to the government sector generate the largest number of jobs, with
2785 24.33 percent of total regional employment. The manufacturing sector ranks second in terms of
2786 overall number of jobs in the analysis area, with 12.61 percent of total regional employment.
2787 Employment related to health and social services ranks third, making up 10.66 percent of total
2788 regional employment.

2789 Employment related to the agricultural sector makes up 4.3 percent of the total employment in the
2790 area. Employment within the agricultural sector is mostly related to grain farming at 33.69 percent,
2791 with all other crop farming at 20.91 percent.

2792 Labor income in this area is estimated at \$3,235,000. The largest contributions to labor income are
2793 made by the government (30.93 percent) and manufacturing (18.12 percent) sectors. The health
2794 and social services sector ranks third, making up 11.43 percent of total labor income in the area.

2795 Output (sales) equals \$10,069,890. The manufacturing industry leads the area in output (sales) at
2796 30.97 percent of the total. The agricultural sector ranks second at 14.61 percent.

2797 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

2798 The potential water supply socioeconomic effects in Region D were measured in the John Day
2799 area which is composed of Oregon’s Morrow and Umatilla Counties and Washington’s Benton
2800 and Klickitat Counties.

2801 Employment in the John Day area is approximately 165,455 jobs (full time and part time). Activities
2802 related to the government sector generate the largest number of jobs, with 12.88 percent of total
2803 regional employment. The agricultural sector ranks second in terms of overall number of jobs in the
2804 analysis area, with 11.12 percent of total regional employment. Employment within the agricultural
2805 sector is related to support activities for agriculture (30.88 percent), fruit farming (29.60 percent),
2806 and vegetable farming (14.59 percent).

2807 Labor income in this area is estimated at \$9,788,130. The government and professional, scientific,
2808 and technical services sectors make the largest contribution to labor income (15.09 percent and
2809 13.02 percent, respectively).

2810 Output (sales) equals \$27,709,430. The manufacturing industry leads the area in output (sales) at
2811 17.24 percent of the total. The professional, scientific, and technical services sector ranks second at
2812 9.49 percent.

2813 **3.12.3 Environmental Consequences**

2814 Water supply in the affected regions is largely driven by water surface elevation, where either
2815 the reservoir elevation is high enough for the pumps to operate or it is not. Efficiencies (i.e., the
2816 amount of energy required to pump a volume of water) can also be affected by reservoir
2817 elevation; this analysis only considers negative effects to efficiencies in reaches where reservoir
2818 elevations drop below historical operating elevations but pumps are still able to operate.

2819 Anticipated water surface elevation based on measure descriptions in the affected reaches is
2820 used as a key indicator to assess environmental consequences of each measure. For example,
2821 the Ice Harbor Project has a minimum operating elevation of 437 feet NGVD29. In some cases,
2822 the intended operation described in a measure could not be modeled; in those cases, the
2823 described operation in the measure was used for the water supply analysis. Pumps in this
2824 reservoir were designed to work with this MOP. If the reservoir was lowered because the dam
2825 was breached (as analyzed in MO3), these pumps would no longer be able to operate. See
2826 Appendix N, *Water Supply*, for additional information on key modeling assumptions that affect
2827 the water surface elevations.

2828 The co-lead agencies went to extensive effort to identify lands irrigated with water from the
2829 potentially affected reaches. The co-lead agencies used available water rights place-of-use and
2830 point-of-diversion area to identify lands that received water from individual reaches. USDA data
2831 was then used to identify crops that had been grown on those lands between 2013 and 2017.
2832 Detailed information about how this data was derived can be found in Appendix N, *Water*
2833 *Supply*, along with the limitations of this data.

2834 Estimates of pumping costs for the John W. Keys Pumping Plant (pumping from Lake Roosevelt
2835 for the Columbia Basin Project) were calculated using a spreadsheet that calculates pump
2836 volume and the energy required to pump that volume with respect to reservoir elevation. The
2837 energy (current average) required to pump 1 acre-foot of water from Lake Roosevelt to Banks
2838 Lake is 333 kilowatt hours (kWh) and the increase in energy to pump the same 1 acre-foot of
2839 water 1 foot higher (i.e., if Lake Roosevelt were 1 foot lower for an alternative) is an additional
2840 1.19 kWh of energy. The current cost of energy for the Columbia Basin Project is \$0.003616 per
2841 kWh using the Columbia Basin Diversion Rate Methodology and Process of CY 2015–2019.

2842 The socioeconomic analysis was driven by the physical water supply effects. If changes to the
2843 water surface elevations affect the ability of the pumps to continue to deliver water to the
2844 irrigated lands, this, in turn, affects the value of crop production from those lands. The areas of

2845 irrigated lands receiving water from these pumps were estimated using the USDA Cropland
2846 Data Layer. These acreage estimates were the basis for cropland acreages and cropping
2847 patterns in the socioeconomic analysis. The potential effects to M&I water deliveries were also
2848 analyzed based on the physical water diversions that may be affected. These analyses are
2849 discussed in detail in Appendix N, *Water Supply*.

2850 The proposed alternatives were analyzed using two economic measures: (1) the social welfare
2851 effects, or direct effects; and (2) the regional economic effects. A regional economic effects
2852 analysis is distinctly different from the social welfare analysis. The regional impact analysis is a
2853 measure of regional activity, whereas the social welfare analysis is a measure of economic
2854 benefits to the nation as a whole. Additionally, the socioeconomic analysis evaluated the MOs
2855 for other social effects.

2856 The results of the social welfare analysis and the regional economic impact analysis are not
2857 directly comparable because they do not measure the same effects. The social welfare analysis
2858 measures net benefits, which represent the value of a resource or resource-related activity to
2859 society. The regional impact analysis measures regional effects, which are flows of money (or
2860 employment) into or out of a defined region. The regional effects from an action may result in
2861 substantial increases in income or employment within a specific region but may generate little
2862 or no benefits to society at the national level. It is also possible that an action may result in
2863 reduced regional output and income in a particular area while generating positive benefits to
2864 the nation as a result of potential environmental enhancement activities or other
2865 improvements that are not translated into actual money flows.

2866 The IMPLAN model was used to estimate the regional economic effects to employment, output
2867 (sales), and labor income. Employment measures the number of jobs (full-time, part-time, and
2868 temporary) related to each industry sector of the regional economy. Labor income is the sum of
2869 employee compensation and proprietor income. Industry output (sales) represent the value of
2870 goods and services produced by businesses within a sector of the economy.

2871 IMPLAN is a static model that estimates impacts for a snapshot in time when the impacts are
2872 expected to occur, based on the makeup of the economy at the time of the underlying IMPLAN
2873 data. IMPLAN measures the initial impact to the economy but does not consider long-term
2874 adjustments as labor and capital move into alternative uses. This approach is used to compare
2875 the alternatives. Realistically, the structure of the economy will adapt and change; therefore,
2876 the IMPLAN results can only be used to compare initial relative changes between the No Action
2877 Alternative and MOs and cannot be used to predict or forecast future employment, labor
2878 income, or output (sales).

2879 While the social welfare effects and regional economic effects are focused on quantifying and
2880 monetizing (when possible) the effects of the MOs, other social effects will consider those more
2881 intangible or qualitative effects that could be experienced at an individual, group, or
2882 community level in order to provide a more complete understanding of potential effects. Other
2883 social effects may include urban and community effects not described as part of the economic
2884 analyses.

2885 There are no anticipated effects to water supply in Canada under any alternative.

2886 **3.12.3.1 No Action Alternative**

2887 The No Action Alternative was designed to continue to supply water to existing users as it has in
2888 the recent past. Because the model assumes that an average diversion representative of
2889 current conditions was diverted every year, regardless of conditions, water supply from surface
2890 water resources would not be impacted under the No Action Alternative.

2891 For there to be effects to groundwater deliveries, the elevations in the streams and reservoirs
2892 would have to drop below historical elevations. For the No Action Alternative, it is not
2893 anticipated that the elevations in any of the streams or reservoirs would affect nearby
2894 groundwater wells because the operation is representative of the historical range.

2895 Socioeconomic results for the No Action Alternative are described here for Regions A, B, C, and
2896 D for a comparative baseline.

2897 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

2898 In Region A under the No Action Alternative, approximately 675,000 acre-feet of water would
2899 be diverted on an average annual basis for irrigation with a portion of that water returning to
2900 the rivers and return flows (Bonnevill 2011b). In the counties surrounding Region A,
2901 approximately 31,000 acre-feet of water would be diverted for M&I purposes from both
2902 surface and groundwater (USGS 2018a; Table 3-).

2903 In Region A, the socioeconomic effects for the MO conditions were estimated as the increment
2904 between the No Action Alternative and the MO conditions. Therefore, effects were not
2905 estimated for the No Action Alternative.

2906 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

2907 In Region B under the No Action Alternative, approximately 3.318 Maf would be diverted from
2908 Lake Roosevelt at the John W. Keys Pumping Plant for agricultural and M&I use to the Columbia
2909 Basin Project with a portion returning to the river as return flow (Bonnevill 2011b). An
2910 additional 35,500 acre-feet would be diverted from Lake Roosevelt by non-Federal users for
2911 irrigation and an additional 16,860 acre-feet for M&I uses (USGS 2018a; Table 3-269).

2912 In Region B, the socioeconomic effects for the MO conditions were estimated as the increment
2913 between the No Action Alternative and the MO conditions. Therefore, effects were not
2914 estimated for the No Action Alternative.

2915 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE
2916 HARBOR DAMS**

2917 In Region C under the No Action Alternative, an average of approximately 316,000 acre-feet of
2918 water would be diverted annually for irrigation, with a portion of that water returning to the

2919 river as return flows (Bonneville 2011b). In the counties surrounding Region C, approximately
2920 21,330 acre-feet is diverted for M&I purposes (USGS 2018a; Table 3-272).

2921 **Social Welfare Effects**

2922 ***Irrigation***

2923 This analysis used a land value approach to estimate benefits or social welfare effects related to
2924 irrigation. The irrigation social welfare effect was based on the land’s income-producing
2925 capability from farm production. The land value method calls for a with and without
2926 comparison of irrigated and non-irrigated lands. When using land values to estimate the social
2927 welfare effects of irrigation water, the land values used for estimating the value of the water
2928 must be based on the land’s income-producing capability from crop production. Appraisers
2929 generally refer to land values based on the land’s income-producing capability as “value in use”
2930 rather than a market value (American Society of Farm Managers and Rural Appraisers 2000).

2931 The analysis used two datasets to estimate the irrigation benefit values. The first estimate
2932 relied on County Assessor estimates of farm-use values. The second estimate used USDA
2933 farmland value survey estimates for Washington.

2934 Walla Walla County data was used for the land value approach. Almost 80 percent of the lands
2935 in the analysis area are in Walla Walla County. The Walla Walla County Assessor’s Office
2936 provided an extensive public dataset related to assessed values, along with GIS mapping. Based
2937 on this available data and the location of the lands, Walla Walla County Assessor data was
2938 considered representative for the analysis area.

2939 The productive value of land varies depending upon quality and location. Land parcels are
2940 classified based on quality and productivity. This analysis used Class 1 lands for estimating the
2941 productive use of irrigated land (with condition) and dryland pasture use values (without
2942 condition). Table 3-276 shows the benefit value calculation in 2019 dollars for the “with” and
2943 the “without” conditions using the assessor’s data. Class 1 land generally has soils that have few
2944 limitations restricting their use. Highly valued crops are often grown on Class 1 land, which is
2945 appropriate for this analysis given the cropping pattern within this analysis area. The USDA
2946 farmland values are used for a comparison. The USDA values are state-level averages for
2947 irrigated land of unknown soil classification.

2948 **Table 3-276. Benefit Values Assuming Dryland Pasture as the Without Condition**

Benefit	Data Source	Price Level	With Condition (Irrigated Crops) \$/per acre	Without Condition (Dryland Pasture) \$/per acre	Benefit Value (With minus Without) \$/per acre
Irrigated Crop Production	Assessor data	2019	\$353.74	\$0.00	\$353.74
Irrigation Crop Production	USDA farmland data	2019	\$284.53	\$28.34	\$256.19

2949 The social welfare effect or economic value for irrigation water (per acre) is the difference
2950 between the Class 1 value less the dryland value in 2019 dollars (\$353.74/acre). The Walla
2951 Walla County Assessor data estimated the dryland rental rate (see Appendix N, *Water Supply*
2952 for discussion) as less than \$2 per acre; therefore, it was assumed to be zero for the purposes
2953 of this analysis. The per-acre value was multiplied by the total number of acres under the No
2954 Action Alternative (47,926 acres). The acreage total includes both socioeconomic analysis areas
2955 within Region C (47,840 acres in the Ice Harbor and Lower Monumental area; 86 acres in the
2956 Little Goose and Lower Granite area)⁹. The annual values were discounted over the 50-year
2957 period using the discount rate of 2.75 (2020 Federal planning rate) to calculate the total
2958 present value. The total present value was then amortized over the same 50-year period and at
2959 the same discount rate to calculate the annual equivalent benefit value. The present value
2960 equals \$ 458,099,362 (annual equivalent value is \$16,953,343). By contrast, using the USDA
2961 farmland values, the present value equals \$331,770,447 (annual equivalent value is
2962 \$12,278,162). These calculations are shown in Table 3-277.

2963 **Table 3-277. Irrigation Water Supply Social Welfare Effects under the No Action Alternative**

	Irrigated Crops (acres)	Price Level	Benefit Value (\$/per acre)	Total Benefit Value Annual Equivalent	Total Benefit Value Present Value
Assessor Data	47,926	2019	\$353.74	\$16,953,343	\$458,099,362
USDA Data	47,926	2019	\$256.19	\$12,278,162	\$331,770,447

2964 ***Municipal and Industrial***

2965 The effects for the MO conditions were estimated as the increment between the No Action
2966 Alternative and the MO conditions. Therefore, effects were not estimated for the No Action
2967 Alternative.

2968 **Regional Economic Effects Analysis**

2969 The regional economic effects analysis estimated effects in two separate analysis areas within
2970 Region C. The Ice Harbor and Lower Monumental socioeconomic analysis area includes the
2971 following counties in Washington State: Columbia, Franklin, and Walla Walla. The Lower
2972 Granite and Little Goose socioeconomic analysis area includes Nez Perce County in Idaho and
2973 Asotin, Garfield, and Whitman Counties in Washington.

2974 ***Irrigation – Ice Harbor and Lower Monumental Dams***

2975 The available water rights place-of-use and point-of-diversion data was used to identify lands
2976 that receive water from these reaches, as discussed in Section 3.12.1.1. Table 3-278 shows the
2977 estimated gross value of production for the crops grown in the Ice Harbor and Lower
2978 Monumental socioeconomic area. The No Action Alternative supports approximately 47,840
2979 acres of farmland in the Ice Harbor and Lower Monumental area and includes fruit crops, small

⁹ Region C was broken into two separate areas for the regional economic effects: the Ice Harbor and Lower Monumental socioeconomic analysis area; and the Little Goose and Lower Granite socioeconomic analysis area. These areas are described in the affected environment section.

2980 grains, irrigated vegetables, grapes, and hay. According to the National Agricultural Statistics
2981 Service (NASS), the total fruit crop acreage in Columbia, Franklin, Walla Walla county equals
2982 approximately 34,000 acres for 2017. The fruit crop acreage in the Ice Harbor and Lower
2983 Monumental socioeconomic area (a smaller subset of the three counties) accounts for 15,800
2984 acres or 46 percent of the total fruit acreage in all three counties. The total grape acreage,
2985 according to NASS, is approximately 5,500 acres for 2017, compared to 3,000 acres of grapes
2986 (55 percent of the all the grape acreage in the entire three counties), and based on these
2987 statistics approximately half of the total fruit crop and grape acreage in all of Columbia,
2988 Franklin, and Walla Walla Counties.

2989 The gross value of production was calculated for each representative crop and was run through
2990 IMPLAN to estimate the regional effects for this alternative (Appendix N, *Water Supply*)
2991 describes how the gross value of production was derived). The regional effects include
2992 estimated employment, labor income, and output (sales) stemming from the gross value of
2993 production.

2994 The No Action Alternative would result in maintaining approximately 4,800 jobs (full-time, part-
2995 time, and temporary jobs) within the Ice Harbor and Lower Monumental analysis area. These
2996 jobs are the result of gross farm income generated from crop production on approximately
2997 47,840 acres of farmland. These jobs account for approximately 5.9 percent of the total jobs in
2998 the analysis area as shown in the affected environment section. The fruit farming sector
2999 impacts of almost 2,800 jobs account for 57 percent of the impacted employment total of 4,800
3000 jobs.

3001 Labor income resulting from the implementation of the No Action Alternative would equal
3002 \$232,000,000, or 5.4 percent of the total labor income in the area. Output (sales) would equal
3003 \$460,500,000, or 3.6 percent of the total output in the area (Table 3-278).

3004 **Table 3-278. Estimated Gross Value of Production and Associated IMPLAN Sector for the Ice**
3005 **Harbor and Lower Monumental Socioeconomic Analysis Area under the No Action Alternative**

Representative Crops	Acres	Gross Value	IMPLAN Sector
Irrigated Alfalfa	2,134	\$2,958,223	All other crops
Irrigated Winter Wheat	10,747	\$6,041,015	Grain farming
Corn	4,014	\$3,677,383	Grain farming
Potatoes	12,131	\$56,213,352	All other crops
Apples	15,801	\$230,013,500	Fruit farming
Grapes	3,013	\$16,212,745	All other crops
Total	47,840	\$315,116,219	

3006 ***Irrigation – Lower Granite and Little Goose Area***

3007 Effects in this area were not modeled due to the small number of acres (less than 90) that were
3008 shown to be impacted. This small number of acres would have a positive effect to employment,
3009 labor income, and output (sales); however, it is too small to measure using IMPLAN.

3010 **Municipal and Industrial**

3011 The effects for the MO conditions were estimated as the increment between the No Action
3012 Alternative and the MO conditions. Therefore, effects were not estimated for the No Action
3013 Alternative.

3014 **Other Social Effects Analysis**

3015 Other social effects capture additional effects that are not measured in the social welfare or
3016 regional economic effects analysis. For water supply, these may include rural lifestyle or
3017 regional growth opportunities. No effects to other social effects are anticipated under this
3018 alternative.

3019 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3020 In Region D under the No Action Alternative, an average of approximately 530,000 acre-feet of
3021 water would be diverted annually for irrigation, with a portion of water returning to the river as
3022 return flows (Bonneville 2011b). In the counties surrounding Region D, about 34,400 acre-feet
3023 are diverted for M&I purposes (USGS 2018a; Table 3-274). In Region D, the socioeconomic
3024 effects for the MO conditions were estimated as the increment between the No Action
3025 Alternative and the MO conditions. Therefore, effects were not estimated for the No Action
3026 Alternative.

3027 **SUMMARY OF EFFECTS**

3028 Under the No Action Alternative, there would be negligible or no change from recent historical
3029 conditions with respect to water supply from surface water resources as well as from
3030 groundwater. In Region C, the social welfare effect of irrigation is estimated to be between
3031 \$12.28 million and \$16.95 million and the regional economic impact across nearly 48,000 acres
3032 of farmland that generates approximately 4,800 jobs, \$232 million in labor income, and \$461
3033 million in total output (sales). In Region D, the effects were estimated as an increment between
3034 the No Action Alternative and MOs; therefore, there were no effects measured for the No
3035 Action Alternative.

3036 **3.12.3.2 Multiple Objective Alternative 1**

3037 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

3038 The reaches below Libby and Hungry Horse may experience lower river stage in some years due
3039 to decreased outflows; however, the lower stages are not anticipated to affect the pumps'
3040 ability to operate, either due to downstream backwater effects or because the change in water
3041 surface elevation would not be measurable in the stream. Therefore, it is anticipated that water
3042 deliveries will still occur.

3043 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

3044 In Region B, multiple measures impact reservoir elevations in Lake Roosevelt, which could
3045 impact the pump efficiency at the John W. Keys Pumping Plant. The plant will be able to
3046 operate at all elevations in order to deliver sufficient supply to the Columbia Basin Project but
3047 pumping costs could increase if reservoir elevations are lower than the No Action Alternative.
3048 Using the average reservoir elevations from MO1 as compared to the No Action Alternative,
3049 estimated pumping cost could increase by approximately \$7,000 annually to deliver current
3050 water supply and by \$10,000 annually to deliver the current plus additional water supply (see
3051 Water Supply Measures). The non-Federal users around Lake Roosevelt may also experience
3052 increased pumping costs, but the effect is expected to be small in comparison to the John W.
3053 Keys effect and is considered to be a negligible effect overall.

3054 **Social Welfare Effects**

3055 ***Irrigation***

3056 This analysis assumes that the currently irrigated lands would remain in production. This level
3057 of production would require increased pumping costs. Due to the drawdown, pump efficiencies
3058 would change, requiring more energy to pump the same quantity of water to the irrigated
3059 lands. The analysis assumes an increase to pumping costs of \$7,000 annually.

3060 The annual pumping costs, which represent the additional pumping cost over the No Action
3061 Alternative, were discounted over the 50-year period of record using the 2020 Federal planning
3062 rate (2.75 percent). The annual equivalent value equals \$7,000 (\$189,000 total present value).
3063 This value represents a decrease in net farm income across the region under MO1.

3064 **Regional Economic Effects Analysis**

3065 Increased pumping costs would result in lower net farm income across the region, which
3066 translates to farm households having less money to spend within the regional economy.
3067 IMPLAN was used to estimate the regional effects (employment, labor income, and output)
3068 resulting from less money being spent within the study area by farm households. The increased
3069 pumping cost was modeled in IMPLAN as a household income change. The lost employment,
3070 labor income, and output would result from an increase in pumping costs of \$7,000 (annual
3071 equivalent), as described in the Social Welfare Effects section, above. The average annual
3072 employment impact was estimated to be a decrease in employment (less than 1 job), labor
3073 income (\$1,000), and output or sales (\$3,700). These losses are the result of less household
3074 spending within the region because income was assumed to decrease as a result of increased
3075 pumping costs.

3076 **Other Social Effects**

3077 Other social effects capture additional effects that are not measured in the social welfare or
3078 region economic effects analyses. There are no other social effects expected as a result of the
3079 change in pumping costs.

3080 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
3081 **HARBOR DAMS**

3082 The reach below Dworshak may experience lower river stage in some years due to decreased
3083 outflows; however, the lower flows are not anticipated to affect the pumps' ability to operate,
3084 either due to downstream backwater effects or because the change in water surface elevation
3085 would not be measurable in the stream. Therefore, it is anticipated that water deliveries will
3086 still be able to occur.

3087 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3088 No change from the No Action Alternative.

3089 **SUMMARY OF EFFECTS**

3090 Decreases to reservoir elevations and river stage due to operational measures in MO1 may
3091 cause negligible effects to pumping costs for water supply; however, the ability to deliver water
3092 for irrigation and M&I is not expected to be affected. See Appendix N, *Water Supply*, for more
3093 detail.

3094 Changes in pumping cost may cause negligible effects to social welfare and regional economic
3095 effects and no other expected social effects in Region B.

3096 **3.12.3.3 Multiple Objective Alternative 2**

3097 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

3098 The reaches below Libby and Hungry Horse may experience lower river stage in some years due
3099 to decreased outflows; however, the lower flows are not anticipated to affect the pumps'
3100 ability to operate, either due to downstream backwater effects or because the change in water
3101 surface elevation would not be measurable in the stream. Therefore, it is anticipated that water
3102 deliveries will still be able to occur.

3103 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

3104 In Region B, multiple measures impact reservoir elevations in Lake Roosevelt, which could
3105 impact the pump efficiency at the John W. Keys Pumping Plant. The plant will be able to
3106 operate at all elevations in order to deliver sufficient supply to the Columbia Basin Project but
3107 pumping costs could increase if reservoir elevations are lower than the No Action Alternative.
3108 Using the average reservoir elevations from MO1 as compared to the No Action Alternative, the

3109 estimated pumping cost could increase by approximately \$10,000 annually to deliver the
3110 current water supply. The non-Federal users around Lake Roosevelt may also experience
3111 increased pumping costs but the impact is expected to be small in comparison to the John W.
3112 Keys impact.

3113 **Social Welfare Effects**

3114 ***Irrigation***

3115 This analysis assumes that the currently irrigated lands would remain in production. This level
3116 of production would require increased pumping costs. Due to the drawdown, pump efficiencies
3117 would change, requiring more energy to pump the same quantity of water to the irrigated
3118 lands. The analysis assumes an increase to pumping costs of \$10,000 annually.

3119 The annual pumping costs, which represent the additional pumping cost over the No Action
3120 Alternative, were discounted over the 50-year period of record using the 2020 Federal planning
3121 rate (2.75 percent). The annual equivalent value equals \$10,000 (\$270,000 total present value).
3122 This value represents a decrease in net farm income across the region under MO2.

3123 **Regional Economic Effects Analysis**

3124 Increased pumping costs would result in lower net farm income across the region, which
3125 translates to farm households having less money to spend within the regional economy.
3126 IMPLAN was used to estimate the regional effects (employment, labor income, and output)
3127 resulting from less money being spent within the study area by farm households. The increased
3128 pumping cost was modeled in IMPLAN as a household income change. The lost employment,
3129 labor income, and output would result from an increase in pumping costs that is expected to be
3130 \$10,000 (annual equivalent) as described in the Social Welfare Effects section, above. The
3131 average annual employment impact was estimated to be a decrease in employment (less than 1
3132 job), labor income (\$1,500), and output or sales (\$5,000). These losses are the result of less
3133 household spending within the region because income was assumed to decrease as a result of
3134 increased pumping costs.

3135 **Other Social Effects**

3136 Other social effects capture additional effects that are not measured in the social welfare or
3137 region economic effects analyses. There are no other social effects expected as a result of the
3138 change in pumping costs.

3139 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE 3140 HARBOR DAMS**

3141 The reach below Dworshak may experience lower river stage in some years due to decreased
3142 outflows; however, the lower flows are not anticipated to affect the pumps' ability to operate,
3143 either due to downstream backwater effects or because the change in water surface elevation

3144 would not be measurable in the stream. Therefore, it is anticipated that water deliveries will
3145 still be able to occur.

3146 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3147 No change from the No Action Alternative.

3148 **SUMMARY OF EFFECTS**

3149 Decreases to reservoir elevations and river stage due to operational measures in MO2 may
3150 cause negligible effects to pumping costs for water supply; however, the ability to deliver water
3151 for irrigation and M&I is not expected to be affected. See Appendix N, *Water Supply*, for more
3152 detail.

3153 In Region B, changes in pumping cost may cause negligible effects to social welfare and regional
3154 economic effects and no expected other social effects.

3155 **3.12.3.4 Multiple Objective Alternative 3**

3156 MO3 includes measures that could affect availability of current water supply in Region C. This
3157 includes measures to breach dams in this region of the lower Snake River, where water is
3158 diverted for irrigation of lands in Washington. In Regions A, B, and D, decreases to reservoir
3159 elevations and river stage due to operational measures in MO3 may cause negligible effects to
3160 pumping costs for water supply; however, the ability to deliver water for irrigation and M&I is
3161 not expected to be affected. See Appendix N, *Water Supply*, for more detail.

3162 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

3163 The reaches below Libby and Hungry Horse may experience lower river stage in some years due
3164 to decreased outflows; however, the lower flows are not anticipated to affect the pumps'
3165 ability to operate, either due to downstream backwater effects or because the change in water
3166 surface elevation would not be measurable in the stream. Therefore, it is anticipated that water
3167 deliveries will still be able to occur.

3168 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

3169 In Region B, multiple measures impact reservoir elevations in Lake Roosevelt, which could
3170 impact the pump efficiency at the John W. Keys Pumping Plant. The plant will be able to
3171 operate at all elevations in order to deliver sufficient supply to the Columbia Basin Project, but
3172 pumping costs could increase if reservoir elevations are lower than the No Action Alternative.
3173 Using the average reservoir elevations from MO1 as compared to the No Action Alternative, the
3174 estimated pumping cost could increase by approximately \$3,000 annually to deliver current
3175 water supply and by \$4,000 annually to deliver current plus additional water supply (see Water
3176 Supply Measures). The non-Federal users around Lake Roosevelt may also experience increased
3177 pumping costs, but the impact is expected to be small in comparison to the John W. Keys
3178 impact.

3179 **Social Welfare Effects**

3180 ***Irrigation***

3181 This analysis assumes that the currently irrigated lands would remain in production. This level
3182 of production would require increased pumping costs. Pump efficiencies would change due to
3183 the drawdown, requiring more energy to pump the same quantity of water to the irrigated
3184 lands. The analysis assumes an increase to pumping costs of \$3,000 annually.

3185 The annual pumping costs, which represent the additional pumping cost over the No Action
3186 Alternative, were discounted over the 50-year period of record using the 2020 Federal planning
3187 rate (2.75 percent). The annual equivalent value equals \$3,000 (\$81,000 total present value).
3188 This value represents a decrease in net farm income across the region under MO3.

3189 **Regional Economic Effects Analysis**

3190 Increased pumping costs would result in lower net farm income across the region, which
3191 translates to farm households having less money to spend within the regional economy.
3192 IMPLAN was used to estimate the regional effects (employment, labor income, and output)
3193 resulting from less money being spent within the study area by farm households. The increased
3194 pumping cost was modeled in IMPLAN as a household income change. The lost employment,
3195 labor income, and output would result from an increase in pumping costs that is expected to be
3196 \$3,000 (annual equivalent) as described in the Social Welfare Effects section, above. The
3197 average annual employment impact was estimated to be a decrease in employment (less than 1
3198 job), labor income (\$500), and output or sales (\$1,500). These losses are the result of less
3199 household spending within the region because income was assumed to decrease as a result of
3200 increased pumping costs.

3201 **Other Social Effects**

3202 Other social effects capture additional effects that are not measured in the social welfare or
3203 region economic effects analyses. There are no other social effects expected as a result of the
3204 change in pumping costs.

3205 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
3206 **HARBOR DAMS**

3207 MO3 included a structural measure (*Breach Snake Embankment*) that could affect water supply
3208 in this region by breaching the lower four Snake River dams. Currently and in the No Action
3209 Alternative, water is available from the reservoirs of these facilities and from groundwater that
3210 results from the reservoirs. The pumps that supply this water would no longer be operational
3211 once the dams were breached and the nearby groundwater elevations could be substantially
3212 impacted. Chapter 4 analyzes the socioeconomic effects of implementing this measure.

3213 Approximately 48,000 acres are currently irrigated from surface water and groundwater in
3214 Region C, with average diversions estimated to be around 316,000 acre-feet (the diversions

3215 encompass those from the Palouse, lower Snake, and Clearwater Rivers, and thus are likely a
3216 high estimate of diversion for the potentially affected acreage). Currently and under the No
3217 Action Alternative, water is available from the pools of these four lower Snake River dams and
3218 from nearby groundwater. The pumps and wells that supply this water would no longer be
3219 operational once these dams were breached.

3220 There are M&I pumps in the Lewiston area that would likely be impacted by this measure,
3221 along with other small M&I uses along the river. The co-lead agencies identified a total of 16
3222 points of diversion from surface water with a water rights purpose listed as M&I, which may
3223 use up to 9,230 acre-feet per year (USGS 2018a).

3224 The Corps evaluated 15 pumps on Lower Granite Reservoir and indicated that these pumps
3225 used approximately 40,000 acre-feet per year in 1996 (Corps 2002b), with the largest user
3226 being the Potlatch Corporation (now Clearwater Paper). It is unclear if this number is total
3227 consumptive use or only the amount diverted. Over the last 10 years, the Clearwater Paper
3228 Company has been reducing its use by treating the water and returning it to the river
3229 (Clearwater Paper 2019), which could account for the overall reduction in usage in the area.

3230 Groundwater would likely be impacted by this measure, with groundwater elevations having
3231 the potential to drop by the entire height of the dams, i.e., up to 100 feet. This would affect
3232 well users in the region. The water supply team identified approximately 200 groundwater
3233 points of diversion that could be used for M&I or irrigation.

3234 The Corps evaluated wells in this region (Corps 2002b) and reported a similar number of wells
3235 (228) recorded in the region. Of the 228 wells, 180 (79 percent) were found to be functioning
3236 and within the study area. Of these 180 wells, 38 were analyzed using well log data combined
3237 with topographic features, well depth, stratigraphy, and surface elevation to determine which
3238 would be affected by changes in river water surface elevation (Corps 2002b). The Corps found
3239 that 15 of these wells (40 percent) would need to be modified to continue operation under the
3240 dam breaching condition. Extrapolating that number to the 200 groundwater points of
3241 diversion within the study area results in 63 wells that could be affected in the region.

3242 **Social Welfare Effects**

3243 ***Irrigation***

3244 The Corps (2002b) report analyzed dam breaching and its effect on water supply. This analysis
3245 considered several system modifications that would allow for the continuation of water
3246 deliveries to existing farmlands. The report concluded that modifying the existing pump system
3247 was cost prohibitive. For the regional analysis, the report assumed that most of the irrigated
3248 acres of land receiving water from the current pumps would no longer be irrigated. The report
3249 assumed that 21 percent of the irrigated land might support the development of alternative
3250 water supplies to replace lost irrigation water. According to the report, the replacement water
3251 would be used to irrigate some of the fruit orchards and vineyards.

3252 This analysis assumed that all irrigated acres receiving water from the current pumps would no
3253 longer be irrigated. This assumption was based on conversations with several extension agents
3254 in Washington and Oregon. The analysis assumed that there was not a suitable substitute water
3255 source and the annual rainfall would not support a dryland crop rotation such as a
3256 wheat/fallow operation. There was also concern that soil acidity may affect a dryland
3257 wheat/fallow operation on lands that previously supported fruit orchards and vineyards.

3258 Assuming the entire 47,926 acres were no longer irrigated, the present value of the lost social
3259 welfare benefit under MO3 would be \$458,099,362 (annual equivalent value is \$16,953,343). In
3260 contrast, using the USDA farmland values, the present value of the lost social welfare benefits
3261 equal \$331,770,447 (annual equivalent value is \$12,278,162). These estimates are in 2019
3262 dollars.

3263 ***Municipal and Industrial***

3264 In Region C, approximately 21,330 acre-feet of M&I water diversions were estimated in Section
3265 3.12.2.1, the Physical Water Supply affected environment. Two approaches were used to
3266 estimate the social welfare effects of the M&I water supply: the use of water market
3267 transaction data and the cost of an alternative water source that would provide the water
3268 supply. Generally, the M&I benefits are measured based on willingness to pay, or the dollar
3269 amount that an entity is willing to pay to obtain an acre-foot of water.

3270 First, the observed market transaction values were analyzed to derive the value of the M&I
3271 water supply. The observed data was obtained from the Water Transfer Data Base presented by
3272 the Bren School at the University of California, Santa Barbara. This dataset relied on
3273 observation from various issues of the Water Strategist publication. The dataset includes water
3274 trades involving agriculture, urban, recreational, and environmental uses from 1987 to 2009.
3275 Water trades for urban use in Washington and Idaho were used. While the dataset was limited
3276 in the number of observations, it was used to show a comparison to the social welfare effects
3277 estimated using construction cost estimates for pump station and private well modifications.

3278 A second approach for estimating the M&I benefits was based on an approach described in the
3279 P&Gs (Principles and Guidelines) involving using the cost of the most likely alternative. In other
3280 words, using the cost of the water supply alternative that would be implemented in the
3281 absence of the project as an estimate of benefits. This approach is acceptable only if the
3282 alternative is viable in terms of engineering feasibility and financial feasibility. For this
3283 approach, the estimated cost of pump modifications, as found in the Corps (2002b) report, was
3284 used.

3285 As shown in Table 3-279, a weighted average of M&I per water acre-foot value was derived.
3286 The M&I water values were weighted using the estimated surface water and groundwater M&I
3287 diversions discussed in Section 3.12.2.1.

3288 **Table 3-279. Weighted Average per Acre-Foot Municipal and Industrial Value**

State	Estimated M&I Diversions (acre-feet)	Percent	State Average Value (\$/acre-foot)	Weighted Average (\$/acre-foot)
WA	7,030	33%	\$365.35	\$120.41
ID	14,300	67%	\$229.42	\$153.81
Total	21,330	—	—	\$274.22

3289 The physical water supply analysis estimated that 21,330 acre-feet of water is diverted for M&I
3290 purposes. The social welfare effect (annual equivalent) is estimated as \$5,849,112 (\$274.22 per
3291 acre multiplied by 21,330 acre-feet).

3292 The second approach to value the social welfare effects of the M&I water supply relied upon
3293 the estimated costs of pump and well modifications, which were taken from the Corps 2002b
3294 report. This analysis assumes that these modifications would be found feasible in terms of
3295 engineering and financing. These costs were estimated in 1998 dollars and indexed to 2019
3296 using Reclamation’s construction cost trends for pumping plants. Summaries of these costs are
3297 shown in Table 3-280 and Table 3-281.

3298 **Table 3-280. Summary of M&I Water Supply Modification Construction Costs**

Original Costs (1998 dollars)	Low	High
M&I Pump Stations	\$11,514,000	\$55,214,000
Private Wells	\$67,042,000	\$67,042,000
Total	\$78,556,000	\$122,256,000

3299 **Table 3-281. Summary of M&I Water Supply Modification Construction Costs**

Indexed (2019 dollars)	Low	High
M&I Pump Stations	\$19,368,613	\$92,879,850
Private Wells	\$112,776,667	\$112,776,667
Total	\$132,145,280	\$205,656,518
Annualized Value (2.75 percent discount rate and 50-year period of analysis)	\$4,894,800 (\$229.48 per acre-foot)	\$7,617,700 (\$357.14 per acre-foot)

3300 To estimate the social welfare effects, the cost estimates were annualized assuming a 50-year
3301 period of analysis and a 2.75 percent discount rate (2020 Federal planning rate). As shown in
3302 Table 3-280, the annualized social welfare effects range from \$4,894,800 to \$7,617,700. On a
3303 per-acre-foot basis, the social welfare effects range from \$229.48 to \$357.14.

3304 It should be recognized that the physical quantities of water are based on the water rights. This
3305 may lead to an overestimation of the actual water used. The estimates of social welfare effects
3306 of M&I water may be overstated.

3307 **Regional Economic Effects**

3308 ***Irrigation – Ice Harbor and Lower Monumental Dams***

3309 Assuming the entire 47,840 acres were no longer irrigated, gross value of production would
3310 decline by approximately \$313,695,365, as described for the No Action Alternative.

3311 Decreased production would result in the loss of employment, labor income, and output (sales)
3312 in the region equal to what was estimated under the No Action Alternative. Approximately
3313 4,800 jobs (full-time, part-time, and temporary jobs) within the Ice Harbor and Lower
3314 Monumental socioeconomic area were estimated to be lost. These jobs account for
3315 approximately 5.9 percent of the total jobs in the area. The fruit farming sector impacts (almost
3316 2,800 jobs) account for 57 percent of the impacted employment total (4,800 jobs). The
3317 implementation of MO3 would decrease labor income by \$232,000,000 (5.4 percent of the total
3318 labor income in the areas). Output would decline by \$460,500,000 (3.6 percent of the total out
3319 output).

3320 As discussed in the No Action alternative, according to NASS, the total fruit crop acreage in
3321 Columbia, Franklin, and Walla Walla Counties equals approximately 34,000 acres for 2017. The
3322 fruit crop acreage in the Ice Harbor and Lower Monumental socioeconomic area (a smaller
3323 subset of the three counties) accounts for 15,800 acres or 46 percent of the total fruit acreage
3324 in all three counties. The total grape acreage, according to NASS, is approximately 5,500 acres
3325 for 2017 compared to 3,000 acres of grapes (55 percent of the all the grape acreage in the
3326 entire 3 counties). Based on these statistics, this alternative affects approximately half of the
3327 total fruit crop and grape acreage in all of Columbia, Franklin, and Walla Walla Counties.

3328 ***Irrigation – Lower Granite and Little Goose Dams***

3329 Assuming the entire 90 acres were no longer irrigated, the gross value of crop production
3330 would decline relative to the No Action Alternative. Published yields and prices were not
3331 available in this area to measure the gross value of crop production. A decrease in agricultural
3332 production on these 90 acres would result in the loss of employment, labor income, and output
3333 (sales). These losses were too small to quantify.

3334 ***Municipal and Industrial***

3335 The physical water supply analysis estimated that 21,330 acre-feet of water is diverted for M&I
3336 purposes. The social welfare effect (annual equivalent) is estimated as \$5,849,112 (\$274.22 per
3337 acre multiplied by 21,330 acre-feet). This value was estimated based on the wholesale price of
3338 M&I water; therefore, it was modeled in IMPLAN as a loss in household income. This decrease
3339 in household income would have a negative effect on the regional economy in terms of jobs,
3340 labor income, and output (sales). These effects were estimated as a loss of 55 jobs, \$2,261,000
3341 of labor income, and \$7,518,000 of output (sales) annually.

3342 **Other Social Effects**

3343 Other social effects (OSE) capture additional effects that are not measured in the social welfare
3344 or region economic effects analyses. For water supply, these may include rural lifestyle or
3345 regional growth opportunities. In Region C under MO3 conditions, approximately 48,000 acres
3346 were estimated to go out of production. These impacts include approximately half the total
3347 fruit farming and grape producing acres in the three counties. The changes in regional
3348 economic effects including employment may include other social effects associated with rural
3349 lifestyle or regional growth opportunities, particularly those associated with agricultural
3350 production and agricultural support services.

3351 The overall change in M&I deliveries under MO3 would be relatively small compared to the
3352 entire region. These losses in delivery would be unlikely to affect population or regional growth
3353 opportunities in the study area.

3354 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3355 Following the breaching of the lower Snake River dams, there would likely be sediment
3356 transported through the McNary and John Day Reservoirs (see Section 3.3, *River Mechanics*, for
3357 more information). The river mechanics modeling showed that at the location of the large
3358 pumps used for the Umatilla lands near RM 295, there would be fine-grained material that
3359 would reach the pumps. However, it should not affect that pump's ability to operate given that
3360 the intakes are 3 to 4 feet in diameter. Farther upstream, there are some private pumps that
3361 may be impacted by the fine-grained material. Though it would not impede their ability to
3362 deliver water, it would result in a need for more frequent maintenance.¹⁰

3363 **SUMMARY OF EFFECTS**

3364 In Region B, changes in pumping cost may cause negligible effects to social welfare and regional
3365 economic effects and no other expected social effects.

3366 Measures implemented under MO3 could affect delivery of current water supply in Region C
3367 and are expected to result in minor effects to social welfare and major effects to regional
3368 economics. This alternative includes measures to breach dams in this region of the lower Snake
3369 River, where water is diverted for irrigation of lands in Washington. This alternative would
3370 affect both surface water resources and groundwater. In Region C, it is assumed that none of
3371 the approximately 48,000 acres currently being irrigated would continue to be irrigated under
3372 MO3. This would result in a social welfare loss equivalent to the benefits under the No Action
3373 Alternative. As described for the No Action Alternative, this amounts to an annual equivalent
3374 value effect of between \$12.28 million and \$16.95 million (2019 dollars).

¹⁰ Based on conversations with Reclamation's Umatilla Field Office Manager.

3375 In addition to the social welfare losses to irrigation in Region C, under MO3 it is estimated that
3376 there would be additional social welfare losses associated with M&I water supply of between
3377 approximately \$4.9 million and \$7.6 million (annual equivalent values).

3378 There would be adverse regional economic effects in Region C in terms of jobs, labor income,
3379 and output (sales). It is estimated that regional economic effects associated with the loss of
3380 nearly 48,000 acres of farmland equal approximately 4,800 jobs, \$232 million in labor income,
3381 and \$461 million in total output (sales). The regional effects related to municipal and industrial
3382 water supply were estimated as losses of 55 jobs, \$2,261,000 of labor income, and \$7,518,000
3383 of output (sales) annually. Overall, these effects are expected to be major to the region.

3384 In Region C, the changes in regional economic effects, including employment, may include
3385 major effects classified as other social effects where associated with rural lifestyle or regional
3386 growth opportunities, particularly those associated with agricultural production and agricultural
3387 support services.

3388 Measures implemented under MO3 are expected to have minimal effects in Region D. The
3389 effects are expected to be limited to the requirement for more frequent maintenance of some
3390 private pumps in the upstream reach.

3391 **3.12.3.5 Multiple Objective Alternative 4**

3392 MO4 included one operational measure that would affect the ability to deliver water to meet
3393 current water supply. In Regions A, B, and C, decreases to reservoir elevations and river stage
3394 due to operational measures in MO4 may cause negligible to minor effects to pumping costs for
3395 water supply; however, the ability to deliver water for irrigation and M&I is not expected to be
3396 affected. See Appendix N, *Water Supply*, for more detail.

3397 **REGION A - LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

3398 The reaches below Libby and Hungry Horse may experience lower river stage in some years due
3399 to decreased outflows; however, the lower flows are not anticipated to affect the pumps'
3400 ability to operate, either due to downstream backwater effects or because the change in water
3401 surface elevation would not be measurable in the stream. Therefore, it is anticipated that water
3402 deliveries will still be able to occur. Lake Pend Oreille (the lake behind Albeni Falls Dam) could
3403 be up to 2.5 feet lower in the summer in some years. The change in elevation is not lower than
3404 the winter minimum; therefore, the pumps would still be able to operate but at a possibly
3405 higher pumping cost.

3406 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

3407 In Region B, multiple measures impact reservoir elevations in Lake Roosevelt, which could
3408 impact the pump efficiency at the John W. Keys Pumping Plant. The plant will be able to
3409 operate at all elevations in order to deliver sufficient supply to the Columbia Basin Project, but
3410 pumping costs could increase if reservoir elevations are lower than the No Action Alternative.

3411 Using the average reservoir elevations from MO1 as compared to the No Action Alternative,
3412 estimated pumping cost could increase by approximately \$72,000 annually to deliver current
3413 water supply and by \$99,000 annually to deliver current plus additional water supply (see
3414 Water Supply Measures). The non-Federal users around Lake Roosevelt may also experience
3415 increased pumping costs, but the impact is expected to be small in comparison to the John W.
3416 Keys effect.

3417 **Social Welfare Effects**

3418 ***Irrigation***

3419 This analysis assumes that the currently irrigated lands would remain in production. This level
3420 of production would require increased pumping costs. Due to the drawdown, pump efficiencies
3421 would change, requiring more energy to pump the same quantity of water to the irrigated
3422 lands. The analysis assumes an increase to pumping costs of \$72,000 annually.

3423 The annual pumping costs, which represent the additional pumping cost over the No Action
3424 Alternative, were discounted over the 50-year period of record using the 2020 Federal planning
3425 rate (2.75 percent). The annual equivalent value equals \$72,000 (\$1,945,500 total present
3426 value). This value represents a decrease in net farm income across the region under MO4.

3427 **Regional Economic Effects Analysis**

3428 Increased pumping costs would result in lower net farm income across the region, which
3429 translates to farm households having less money to spend within the regional economy.
3430 IMPLAN was used to estimate the regional effects (employment, labor income, and output)
3431 resulting from less money being spent within the study area by farm households. The increased
3432 pumping cost was modeled in IMPLAN as a household income change. The lost employment,
3433 labor income, and output would result from an increase in pumping costs that is expected to be
3434 \$72,000 (annual equivalent) as described in the Social Welfare Effects section, above. The
3435 average annual employment impact was estimated to be a decrease in employment (less than 1
3436 job), labor income (\$11,000), and output or sales (\$38,000). These losses are the result of less
3437 household spending within the region because income was assumed to decrease as a result of
3438 increased pumping costs.

3439 **Other Social Effects**

3440 Other social effects capture additional effects that are not measured in the social welfare or
3441 regional economic effects analyses. There are no other social effects expected as a result of the
3442 change in pumping costs.

3443 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE** 3444 **HARBOR DAMS**

3445 No change from the No Action Alternative.

3446 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3447 MO4 included an operational measure that could affect water supply from the John Day
3448 Reservoir (the *Drawdown to MOP* measure) by lowering the minimum pool during the irrigation
3449 season by 1.5 feet to 261.0 feet NGVD29 (264.2 feet NAVD88). A decrease in water surface
3450 elevation by 1.5 feet would not be outside the range of recent historical operations, so it is
3451 possible that most, if not all, of the pumps would still be operational. However, anecdotal
3452 information suggests that some pumps might need modification to continue operation.
3453 Complete data is not available to analyze the number of pumps requiring modification or the
3454 degree of modification required, so the cost of this modification was not analyzed. For those
3455 pumps that can still operate, the cost to pump that water would likely increase due to the
3456 additional head required for pumping; this cost was analyzed.

3457 There could be effects to water supply to Irrigon and Umatilla Fish Hatcheries, which receive
3458 water from shallow aquifer Ranney wells. The Corps (1994) found that each foot of drawdown
3459 reduced the water supply by 10 percent in a study that evaluated reducing the minimum pool
3460 to 257 feet, which is 4 feet lower than the proposed measure.

3461 This measure could also affect groundwater because the head would be lower for the irrigation
3462 season than under No Action Alternative operations. The 1.5 feet of head difference could
3463 lower groundwater levels up to 1.5 feet (while the relationship may be less than one to one, it
3464 should not result in groundwater level reductions of more than 1.5 feet).

3465 **Social Welfare Effects**

3466 ***Irrigation***

3467 This analysis assumes that the currently irrigated lands (approximately 212,225 acres) would
3468 remain in production. This level of production would require increased pumping costs. Due to
3469 the drawdown, pump efficiencies would change, requiring more energy to pump the same
3470 quantity of water to the irrigated lands.

3471 The additional power requirement was estimated based on a sample of pumps. Available pump
3472 information and use rates were used to estimate the energy requirement to maintain the
3473 operability when the reservoir is lowered the additional 1.5 feet.

3474 The cost of the additional power requirement was valued using power prices for pumping,
3475 which were obtained from the power and transmission analyses (see Section 3.8, *Power and*
3476 *Transmission*). A range of pumping rates (minimum and maximum estimates) was used to
3477 calculate the initial pumping cost or the pumping cost for the first year of the 50-year period of
3478 analysis. The average rate of change from the Power and Transmission (Section 3.8) analysis
3479 was used to calculate the annual pumping costs. This rate of change was applied to the initial
3480 pumping cost estimate to estimate the additional pumping costs over the 20-year period as
3481 shown in Table 3-282. To accommodate a 50-year period of analysis, the forecasted prices were

3482 extended to 50 years. The pumping costs beyond the 20-year period were held constant at the
3483 year 20 estimate to the end of the 50-year period of analysis.

3484 **Table 3-282. Estimated Power Rate and Additional Pumping Costs for Year 1, and Average**
3485 **Annual Rate Increase of the 20-Year Period**

Factor	WA Min	WA Max	OR Min	OR Max
Year 1 Power Rate Estimate	\$0.06010	\$0.06440	\$0.06480	\$0.06790
Year 1 Total Additional Cost	\$80,151	\$90,553	\$201,645	\$211,291
Average Annual Rate Change	-0.6300%	-0.6200%	-0.6500%	-0.6600%

3486 The annual pumping costs, which represent the additional pumping cost over the No Action
3487 Alternative, were discounted over the 50-year period of record using the 2020 Federal planning
3488 rate (2.75 percent). The present values are shown in Table 3-283 along with the annual
3489 equivalent and the estimated per acre increase. These values represent a decrease in net farm
3490 income across the region under MO4. The change in social welfare would be equal to these
3491 estimated differences in pumping costs between the MOs across the 50-year period of analysis.

3492 **Table 3-283. Estimated Social Welfare Effects under Multiple Objective Alternative 4**

Factor	Total (WA and OR)	Acres	\$/Acre
Min Present Value	\$7,014,600	–	–
Min Annual Equivalent	\$259,827.40	212,226	\$1.22
Max Present Value	\$7,496,225	–	–
Max Annual Equivalent	\$277,667.08	212,226	\$1.31

3493 ***Municipal and Industrial***

3494 The physical effects to M&I were not estimated under the MO4 conditions due to lack of data
3495 specific to the pumps. It was assumed that there would be no physical effect to delivering M&I
3496 water.

3497 **Regional Economic Effects**

3498 ***Irrigation***

3499 This analysis assumes that the currently irrigated lands would remain in production; however,
3500 due to changes in pumping efficiencies as a result of the drawdown, increased pumping costs
3501 would be required to maintain irrigation needs. This additional power requirement would result
3502 in additional annual pumping costs estimated at \$260,000 to \$277,700 annually for the entire
3503 study area (see Appendix N, *Water Supply*, for more information).

3504 It is possible that some of the pumps and wells may need to be modified to continue to operate
3505 at the deeper elevation. Due to incomplete data, this was not evaluated for this study. The
3506 Corps evaluated construction cost for modification of pumps and wells in 1994; however, that
3507 study evaluated reducing the elevation down to 257 feet NGVD29 (260.2 feet NAVD88), which

3508 is 4 feet deeper than is proposed in this alternative. Given the uncertainty with indexing and
3509 the unknowns as to which pumps would be impacted at the shallower drawdown, this
3510 information was not used in this study.

3511 Increased pumping costs would result in lower net farm income across the region, which
3512 translates to farm households having less money to spend within the regional economy.
3513 IMPLAN was used to estimate the regional effects (employment, labor income, and output)
3514 resulting from less money being spent within the study area by farm households. The increased
3515 pumping cost was modeled in IMPLAN as a household income change. The lost employment,
3516 labor income, and output would result from an increase in pumping costs that is expected to
3517 range from \$260,000 to \$278,000 (annual equivalent, rounded) as described in the Social
3518 Welfare Effects section, above. The average annual employment impact was estimated to be a
3519 decrease in employment (less than five jobs), labor income (\$55,400 to \$59,000), and output
3520 (\$176,000 to \$188,000).

3521 ***Municipal and Industrial***

3522 The physical effects to M&I water were not estimated under the MO4 conditions due to lack of
3523 data specific to the pumps. It was assumed that there would be no physical effect to delivering
3524 M&I water.

3525 **Other Social Effects**

3526 Other social effects capture additional effects that are not measured in the social welfare or
3527 region economic effects analyses. There are no other social effects expected as a result of the
3528 change in pumping costs.

3529 **SUMMARY OF EFFECTS**

3530 In Region B, there are expected to be negligible effects to social welfare and regional economic
3531 effects as a result of higher pumping costs. No other social effects are expected in Region B.

3532 As a result of the lowering of the reservoir, MO4 includes an operational measure that could
3533 affect water supply from the John Day Reservoir (*the Drawdown to MOP measure*), the water
3534 supply to Irrigon and Umatilla Fish Hatcheries, and groundwater. In Region D, the social welfare
3535 effects of increased pumping costs compared to the No Action Alternative are estimated to
3536 decrease social welfare by between \$7.0 million and \$7.5 million (present value) over the 50-
3537 year period of analysis. This equates to an annual equivalent value over the 50-year period of
3538 between \$260,000 (rounded) and \$278,000 (rounded). These are considered negligible effects.

3539 The regional economic impact of the drawdown under this alternative is expected to be in the
3540 form of lower net farm income in the region as a result of the increase in pumping costs. The
3541 increased cost is estimated to decrease employment by five jobs, decrease labor income by
3542 between \$55,400 and \$59,000, and decrease total output by between \$176,000 and \$188,000.
3543 Overall, MO4 is expected to result in negligible effects to water supply. There are no other
3544 social effects expected as a result of the change in pumping costs.

3545 **3.13 VISUAL**

3546 **3.13.1 Introduction and Background**

3547 The Columbia River Basin landscape is diverse, ranging from rugged forests to arid shrub-steppe
3548 landscapes. From east to west, the viewshed transitions from mountain streams and lakes to
3549 arid valleys and agricultural lands, culminating with the Columbia River Gorge cutting through
3550 the Cascade Range. Visual resources include these landforms, vegetation, water, color, adjacent
3551 scenery, and human-made modifications such as the distinct structures associated with each
3552 CRS project and the infrastructure associated with their authorized uses. Evaluating the visual
3553 qualities of an area, or viewshed, is a process that acknowledges the value that an observer
3554 places on a specific feature varies depending on their perspective and judgment. A qualitative
3555 visual resource assessment was conducted to assess the baseline visual environment and
3556 determine whether alterations associated with the alternatives would alter the visual
3557 environment. Accordingly, this section evaluates changes to the viewshed from the MOs based
3558 on changes in visual qualities such as color, vegetation, and landforms, and how these changes
3559 affect different viewer types.

3560 **3.13.1.1 Area of Analysis**

3561 The analysis area includes the visual environment along the river systems associated with the
3562 14 Federal projects. This includes line-of-sight, observable viewshed features associated with
3563 the river systems and CRS projects depicted in Figure 1-1. The four regions in the area of
3564 analysis are defined in Figure 3-1.

3565 **3.13.2 Affected Environment**

3566 The area of effect, or viewshed, is a portion of the analysis area where an object or visual
3567 intrusion can be seen. It includes all surrounding points that are in the line of sight and excludes
3568 points beyond the horizon or obstructed by terrain or other existing features. The viewshed
3569 includes natural and human-made features. Areas that are seldom seen were not included in
3570 the analysis based on the scale of this EIS.

3571 Project infrastructure is a substantial part of the viewshed and includes concrete dams,
3572 powerhouse and spillway structures, access roads, transmission structures, warning and
3573 navigational buoys, visitor and information centers, and water-passage features for fish
3574 migration and water vessels. Intermittent maintenance and project-improvement activities are
3575 considered to be a part of the viewshed similar to traffic being considered part of the viewshed
3576 within a highway right-of-way. Other infrastructure contributing to the visual environment
3577 includes parks, facilities, and access points that are designed for recreational use or for utilities
3578 such as irrigation or transporting agricultural resources. These may also change periodically
3579 with minimal impact to the overall viewshed. Within these river and reservoir systems, the
3580 natural landscapes constitute much of the viewshed. The topography varies as one travels
3581 down the watershed, fashioning the characteristic landscapes. Steep mountains with their
3582 forested slopes and narrow canyon walls are often accompanied by swift flowing rivers and

3583 heavy spring flows. These landscapes transition into rolling hills and gentle streams with diverse
3584 vegetation or give way to basalt plains. Anthropogenic features are typically concentrated in
3585 specific locations. Rural settings are characterized with sparsely populated homes and extensive
3586 agricultural fields, which wind their way through open valleys. Urban areas include numerous
3587 small and mid-sized towns where sights and sounds are dominated by human development and
3588 activity. The reservoir systems include major alterations to the natural landscapes for the
3589 enormous hydropower infrastructures and for developed recreational facilities. The presence
3590 or absence of water is an important factor in determining visual quality as it adds to or
3591 subtracts from the attractiveness of an area. Throughout the Columbia River Basin, viewsheds
3592 are also important to tribal members engaging in traditional cultural practices or visiting
3593 traditional cultural sites and could be affected by infrastructure (e.g., fish hatcheries, parks,
3594 levees, fencing, signage, access roads).

3595 The geographic regions described above and depicted in Figure 1-1 have varying viewshed
3596 qualities and viewer accessibility:

- 3597 • Region A has river and reservoir systems that cut through rocky uplands and steep
3598 mountains associated with the Kootenai National Forest near Libby, Montana, and the
3599 Flathead National Forest near Hungry Horse, Montana, to semi-forested and arid valley
3600 terrain downriver of these reservoirs. This region is mostly rural with some small- and
3601 moderate-size communities.
- 3602 • Region B is dominated by a mix of rugged basalt, arid, and rocky landscapes dotted with
3603 forests and hills, agricultural features, small- and moderate-sized communities, and some
3604 industrial facilities. Lake Roosevelt is a notable feature created by impoundment with the
3605 construction of Grand Coulee.
- 3606 • Region C has changing landscapes from the more remote Clearwater National Forest around
3607 Dworshak Reservoir in the east to rolling hills and basalt plains in the west. Vegetation along
3608 the river is characterized as shrub steppe with nearby agricultural plots. In addition to
3609 agriculture, other associated land uses include recreation, residential, and shipping ports,
3610 with greater concentrations near the moderate-sized communities.
- 3611 • Region D has arid, basalt plain landscapes in the east with rural viewsheds dotted with
3612 agricultural features and small- to moderate-sized communities. To the west, this landscape
3613 changes with the scenic Columbia River Gorge, which is the portion that runs between the
3614 Gifford Pinchot National Forest on the Washington side and Mount Hood National Forest on
3615 the Oregon side. Numerous state and local parks are located along the riverfront or have
3616 views of the river, which take advantage of the high-quality visual settings of surrounding
3617 natural landscapes.

3618 **3.13.3 Environmental Consequences**

3619 The effects to visual resources are analyzed by systematically measuring the degree of change
3620 created by a proposed alternative. This is done by comparing the basic elements of line, form,
3621 color, and texture within the existing viewshed to those introduced by the alternative. Factors

3622 that need to be considered are distance, viewing times, relative size and scale, season of use
3623 and light conditions, recovery time, spatial relationships, as well as noise and motion.

3624 Impacts to the viewer are determined by analytically measuring the sensitivity of differing
3625 viewer groups. Sensitivity attaches relative importance values to differing landscapes based on
3626 perceived user expectations and activities. Tribal members and recreationalists are among the
3627 most sensitive of all viewing groups. Additionally, viewers are divided into two types: static and
3628 non-static. Static viewers include residents, reservoir and project employees, recreation
3629 management agencies, tribal members, and recreation visitors to an area. Non-static viewers
3630 are mainly defined as people traveling through area or along access roads and may have limited
3631 views of the viewshed. The sensitivity of the different types of viewers varies based on their
3632 perceptions of the area and the importance they place on the landscape, or how they interpret
3633 visual quality. Casual observers are typically engaged in other activities so they may not notice
3634 landscape changes. Sensitive viewers actively view the landscape and have a deeper connection
3635 to the visual environment. Recreationalists and tribal members have the highest sensitivity
3636 level. Even small visual changes may affect the experience for tribal members engaging in
3637 cultural activities or practices.

3638 There are no anticipated visual effects in Canada as a result of the MOs in this EIS.

3639 **3.13.3.1 No Action Alternative**

3640 Under the No Action Alternative, the rivers and reservoirs in the analysis area would experience
3641 seasonal fluctuations. In many cases, such as the run-of-river projects, water surface elevations
3642 remain within a couple of feet throughout the year, but in some instances, the changes are
3643 much larger with reservoir elevation changes of 50 feet or more. With this large potential for
3644 reservoir elevation changes, natural-appearing landscapes would vary dramatically over the
3645 course of a year, affecting the visual quality. The degree of color contrast varies based on the
3646 width of the exposed shoreline during drawdown and the surrounding topography. The stark
3647 differences in form, color, and texture create a band of visual contrast separating vegetation
3648 communities and the surface of the reservoir. Because drawdowns normally occur gradually
3649 over the course of the spring and summer seasons, with lower elevations occurring after the
3650 height of the recreation season, the most severe effects would likely not be noticed by sensitive
3651 viewers. Residents and repeat visitors to the areas have become accustomed to these seasonal
3652 changes and are not substantially affected by the changes to the visual quality. However, tribal
3653 members could be affected by seasonal changes in reservoir levels while engaging in cultural
3654 activities or practices. Other localized and temporary impacts would result from pollution, algae
3655 blooms, plant or animal debris, water color, and turbidity.

3656 Visual effects would vary throughout the year with changes in reservoir elevation, most notably
3657 at the storage projects. These changes depend on natural climate conditions and water
3658 management actions. To characterize the median annual range difference, two values are used:
3659 the uppermost median value and the lowermost median value for typical water years (the
3660 middle 60 percent of water years), each of which typically occur at a given time of year.
3661 For storage reservoirs, the uppermost is usually in the summer, and the lowermost is usually in

3662 the late winter or spring. Reservoir elevations can vary dramatically from year to year, so the
3663 area of exposed shoreline and smaller reservoir varies accordingly, ranging from moderate
3664 during dry and normal years to high during years with large water supply forecast and inflows.
3665 Therefore, the visual quality would experience the same annual variability.

3666 **TRIBAL INTERESTS**

3667 To the extent operational or structural measures affect the viewshed, this can have unique
3668 impacts on spiritual practices for tribes. Per the Tribal Perspectives document submitted by the
3669 Confederated Colville Tribes, these viewsheds are important for vision quests.

3670 “Vision quests are used by tribal members to obtain a guardian spirit, power, or medicine.
3671 These sites are often marked by cairns (Figure 4), although many times they are also left
3672 unmarked (Cline 1938, Ray 1942). Integrity of setting is very important for vision quest sites.
3673 While vision quest sites usually sit great distances from the Columbia River or other rivers,
3674 these rivers often lie in the viewsheds of these sites. The appearance of the river or sounds
3675 coming from the river can affect the setting of a vision quest site. For example, the setting
3676 during the drawdown behind Grand Coulee Dam differs greatly from that during full pool. This
3677 affects the experience for the individual on a vision quest.” (Appendix P, *Tribal Perspectives*)

3678 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

3679 **Operational Measures**

3680 At Libby Dam (Lake Koochanusa), the median annual reservoir elevation ranges from a minimum
3681 of 2,384.2 feet in the spring to a maximum of 2,453.3 feet in the summer for an annual
3682 difference of 69.1 feet. At Hungry Horse Reservoir, the median annual reservoir elevation
3683 ranges from a minimum of 3,521.7 feet in the spring to a maximum of 3,559.7 feet in the
3684 summer for an annual difference of 38.0 feet. At Albeni Falls (Lake Pend Oreille) the median
3685 annual reservoir elevation ranges from a minimum of 2,051.3 feet in the winter to a maximum
3686 of 2,062.3 feet in the summer for an annual difference of 11.0 feet. See Section 3.2.4.3 for
3687 more detailed information on reservoir fluctuation. Viewership during reservoir elevation
3688 changes would be limited to local populations and low visitation times. There would be a
3689 decrease in visual quality during low reservoir elevations. Using the median annual fluctuation,
3690 the degree of change between water, exposed shoreline, and vegetation communities, the
3691 impacts to visual quality would be minor with similar impacts to the casual observer. Reservoir
3692 elevations would vary from year to year, but the level of effect would not substantially change.
3693 More sensitive viewers may experience a moderate effect during years with lower reservoir
3694 levels. Sensitive viewers during reservoir elevation decreases would include tribal members and
3695 recreationalists. Therefore, these viewer groups would experience a moderate effect.

3696 **Structural Measures**

3697 Planned structural changes include an extensive modification of Hungry Horse Dam facilities.
3698 Although these are substantial efforts, the introduced change in visual quality would be

3699 minimal because the alterations mirror the existing structures, retaining the basic design
3700 elements such of line, form, color, and texture of the existing facilities. Construction activities
3701 would draw the attention of casual observers within the immediate area, but the effect would
3702 be minimal and diminish over a 10-year period as the changes are completed. The effect to all
3703 viewers along the rivers and reservoirs in the analysis area would not substantially change and
3704 therefore would be minor.

3705 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

3706 **Operational Measures**

3707 Seasonal fluctuations and drawdown of Lake Roosevelt (Grand Coulee Dam) would affect the
3708 visual quality of the landscape. Lower reservoir levels would expose more of the shoreline,
3709 increasing the contrast between the water surface, shoreline, and vegetation communities.
3710 Subsurface features would be exposed. At Lake Roosevelt, the median annual reservoir
3711 elevation ranges from a minimum of 1,245.6 feet in the spring to a maximum of 1289.5 feet in
3712 the summer for an annual difference of 43.9 feet (Reclamation 2019c; Section 3.2.2.3).
3713 Reservoir elevation changes vary dramatically from year to year so the area of exposed
3714 shoreline and smaller reservoir varies accordingly, ranging from moderate during dry and
3715 normal years to high during years with extreme fluctuation in reservoir level. The expansion of
3716 the shoreline during periods of low reservoir levels would result in a minor degree of change
3717 with minimal effect to visual quality. During the winter months, changes in atmospheric
3718 conditions and snow cover would reduce the overall color contrast, which would further
3719 mitigate some of these effects. Effects to the casual observer and some sensitive viewers would
3720 be minor because the higher visitation periods at Lake Roosevelt correspond with higher
3721 reservoir elevations.

3722 **Structural Measures**

3723 Planned structural changes at Grand Coulee include the modernization of the third power
3724 house. Effects to visual resources would be limited to construction activities that occur outside
3725 of the existing buildings and would include the visual intrusions created by the placement of the
3726 temporary buildings and the development of staging area. The overall visual quality would not
3727 be substantially impacted because the elements of line, form, and color produced by the dam
3728 would not change over the long term. The temporary buildings and staging areas that would be
3729 visible vary in locations within 5 miles of the dam. During the life of the project, the increase in
3730 activity would be seen and may draw the attention of the casual observer. Because the dam
3731 facilities are important to local communities, this is not likely to conflict with the viewer
3732 expectations and impacts to all viewer groups would be minor.

3733 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
3734 **HARBOR DAMS**

3735 **Operational Measures**

3736 Visual effects would occur annually at Dworshak. These changes in reservoir elevation would be
3737 dependent on natural climate conditions and water management actions. At Dworshak
3738 Reservoir, the median annual reservoir elevation ranges from a minimum of 1,518.8 feet in the
3739 spring to a maximum of 1,600.0 feet in the summer for an annual difference of 81.3 feet
3740 (Section 3.2.4.3).

3741 Timing for operation of spill volume at the run-of-river projects on the lower Snake River would
3742 be weather dependent and in association with juvenile fish passage program objectives.
3743 The degree of change could vary sharply from year to year based on the actual decrease in the
3744 reservoir levels and therefore would range from minor to moderate depending on
3745 environmental conditions. Viewer effects during Dworshak Reservoir elevation decreases would
3746 be experienced by casual observers and sensitive viewing groups. Because the reservoir would
3747 be drawn down in the summer and early fall, which coincides with the timeframe for peak
3748 recreational use, the effect to visual sensitivity would be higher for recreationalists. Therefore,
3749 while the impacts would be minor to local populations who are accustomed to the seasonal
3750 fluctuations, the impacts to more sensitive viewers would be moderate.

3751 **Structural Measures**

3752 Visual effects may be observable from structural changes to projects and infrastructure for
3753 maintenance, which may draw the attention of the casual observer, resulting in a moderate
3754 degree of change. However, these types of activities would be short term during construction
3755 or maintenance. Structural modifications would also have negligible effects on visual quality,
3756 but they would be long term. Impacts to the sensitive viewers in the vicinity of those
3757 construction activities would be minor.

3758 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3759 **Operational Measures**

3760 Visual quality effects would vary throughout the year with changes in reservoir elevation at the
3761 projects located within Region D. These changes in reservoir elevation would depend on natural
3762 climate conditions and water management actions. Columbia River dams vary river and
3763 reservoir elevation by a few feet. Timing of visual effects through operational changes in spill
3764 volume would be weather dependent and in association with juvenile fish passage program
3765 objectives. With minimal change in elevation, the effect on visual quality, as well as effect on
3766 casual observers and sensitive viewers, would be minor.

3767 **Structural Measures**

3768 Visual effects may be observable from structural changes to projects and infrastructure for
3769 maintenance projects and ongoing fish migration improvements (Section 2.3.2.1.), which may
3770 draw the attention of the casual observer, resulting in a moderate degree of change. However,
3771 these types of activities would be short term during construction or maintenance. Structural
3772 modifications would also have negligible effects on visual quality, but they would be long term.
3773 Effects to the sensitive viewers in the vicinity of those construction activities would be minor.

3774 **SUMMARY OF EFFECTS**

3775 Under the No Action Alternative, short-term impacts would continue to result in both minor
3776 and moderate visual quality impacts associated with seasonal changes in reservoir elevations
3777 and maintenance activities. The impacts to the casual observer would be minimal; however,
3778 sensitive viewers may continue to experience moderate impacts. Structural changes would
3779 occur with a minimal impact to visual quality, and with minor impacts to all viewer groups.

3780 **3.13.3.2 Multiple Objective Alternative 1**

3781 Under this alternative, changes to reservoir elevation would occur due to operational changes
3782 at storage projects. Lower elevations would have similar impacts to those described for the No
3783 Action. However, the degree of change between exposed shoreline, water, and vegetation
3784 communities would differ based on the variations in the timing, duration, and the rate of the
3785 drawdowns. Seasonal changes in reservoir elevation include periods of higher reservoir
3786 elevations, which would benefit visual quality by reducing the exposed shoreline and creating a
3787 more natural-appearing landscape. In addition to changes in reservoir elevations, river flows
3788 and stages in the region would change relative to the No Action Alternative (see Table 2-3 and
3789 Section 2.3.3.1). Increased flows may create localized water turbidity which may alter water
3790 color and clarity. Scheduling of operational changes in management of reservoir elevation at
3791 Hungry Horse, Libby, Grand Coulee, Albeni Falls, Dworshak, and John Day Dams may affect the
3792 seasonal timing and duration of changes to visual quality and would have a minor effect on
3793 sensitive viewers and a negligible effect on the casual observer.

3794 For Regions A and B, visual effects from structural changes to projects and infrastructure for
3795 construction and maintenance (see Table 2-3 and Section 2.3.3.1) would be the same as
3796 described for the No Action Alternative. Structural changes for MO1 include specific
3797 modifications to lower Columbia and lower Snake River projects for fish passage. These types of
3798 activities would be short term during construction or maintenance and would have a minor,
3799 short-term visual effect on casual observers in the immediate vicinity of the project. Therefore,
3800 Regions A and B are not discussed further under MO1.

3801 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
3802 **HARBOR DAMS**

3803 **Operational Measures**

3804 Scheduling operational changes in the management of reservoir elevation at Dworshak Dam
3805 and the lower Snake River projects may affect the seasonal timing and duration of changes to
3806 visual quality and may have a minor effect on all viewer groups in the immediate vicinity.

3807 **Structural Measures**

3808 Modification of project passage facilities such as upgrades to spillway weirs, modifications to
3809 fish ladders, and installation of passage routes at the lower Snake River projects would create a
3810 low degree of change by retaining the existing line, form, color, and texture. The impacts
3811 related to these activities would be minor and short term. While new structures could result in
3812 moderate changes to the existing viewshed, visual quality impacts would generally be minor
3813 with a similar level of effect to the casual observer in the vicinity of those construction
3814 activities.

3815 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3816 **Operational Measures**

3817 Operational changes at John Day Reservoir would result in minimal change to reservoir
3818 elevation over a few months. The casual observer near the project would likely not notice the
3819 change compared to changes in reservoir elevation that occur annually as described under the
3820 No Action Alternative.

3821 **Structural Measures**

3822 Modification of project passage facilities such as upgrades to spillway weirs, modifications to
3823 fish ladders, and installation of passage routes at the lower Columbia River projects would
3824 result in visual impacts similar to those described for Region C.

3825 **SUMMARY OF EFFECTS**

3826 Overall, the operational and structural measures under MO1 would have a similar effect on the
3827 visual quality and to all viewer groups as under the No Action Alternative. There may be a
3828 moderate effect to visual quality from new fish passage structures, with only a minor effect to
3829 modifications fish passage structures, modifications to fish ladders, and changes to spillway
3830 weirs at the lower Columbia River projects in Region D and the lower Snake River projects in
3831 Region C, but overall, the effects from MO1 would be minor.

3832 **3.13.3.3 Multiple Objective Alternative 2**

3833 Operational change effects to visual resources are also similar to the No Action Alternative with
3834 additional focus on increasing hydropower generation by limiting spill at the lower Columbia
3835 and lower Snake River projects and allowing flexibility in reservoir elevations as described in
3836 Section 2.3.4.1. These changes are not likely to add additional effects to the viewshed from
3837 what is previously described for the No Action Alternative. Similar to MO1, MO2 would include
3838 specific modifications to the lower Columbia and lower Snake River projects for fish passage.
3839 For Regions A and B, structural changes to projects and infrastructure may be necessary for
3840 maintenance and are described under the No Action Alternative. These types of activities would
3841 be short term during construction or maintenance activities and would be a minor visual effect
3842 to viewers in the immediate vicinity of the project; therefore, Regions A and B are not discussed
3843 further under MO2.

3844 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
3845 **HARBOR DAMS**

3846 **Operational Measures**

3847 Scheduling operational changes in the management of reservoir range operations at the four
3848 lower Snake River projects may have a minor effect on sensitive viewers. The casual observer
3849 would likely experience effects, but to a lesser extent, because changes in reservoir operations
3850 occur annually as described under the No Action Alternative.

3851 **Structural Measures**

3852 Modification of project passage facilities such as upgrades to spillway weirs, modifications to
3853 fish ladders, and installation of passage routes at the lower Snake River projects would create a
3854 low degree of change by retaining the existing line, form, color, and texture. The impacts
3855 related to these activities would be minor and short term. While new structures could result in
3856 moderate changes to the existing viewshed, visual quality effects would generally be minor
3857 with a similar level of effect to the casual observer in the vicinity of those construction
3858 activities.

3859 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3860 **Operational Measures**

3861 Operational changes at John Day Reservoir would result in minimal change to pool elevation.
3862 The casual observer would not likely notice the change compared to changes in reservoir
3863 elevation that occur annually as described under the No Action Alternative.

3864 **Structural Measures**

3865 Modification of project passage facilities such as upgrades to spillway weirs, modifications to
3866 fish ladders, and installation of passage routes at the lower Columbia River projects would
3867 result in visual impacts similar to those described for Region C.

3868 **SUMMARY OF EFFECTS**

3869 Overall, the operational and structural measures under MO2 would have a similar effect on
3870 visual quality and to viewers as under the No Action Alternative. There may be a minor effect
3871 from new fish passage structures, modifications to fish ladders, and changes to spillway weirs at
3872 the lower Columbia River projects in Region D and lower Snake River projects in Region C, but
3873 overall, the effects from MO2 would be minor.

3874 **3.13.3.4 Multiple Objective Alternative 3**

3875 Effects from operational changes for MO3 are similar to those described under the No Action
3876 Alternative with regard to changes in management of reservoir elevation for storage projects,
3877 and changes that would increase spill as described in Section 2.3.5.1. Substantial structural
3878 changes would occur at the four lower Snake River projects to return this portion of the Snake
3879 River to a free-flowing river. This would result in a high degree of change within the existing
3880 viewshed from a series of impounded reservoirs changing to free-flowing riverine conditions.
3881 Structural changes also include specific modifications to lower Columbia River projects for fish
3882 passage. For Regions A and B, structural changes to projects and infrastructure may be
3883 necessary for maintenance and are described under the No Action Alternative. These types of
3884 activities would be short term during construction or maintenance activities and would result in
3885 a minor visual effect to viewers in the immediate vicinity of the project; therefore, Regions A
3886 and B are not discussed further for MO3.

3887 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
3888 **HARBOR DAMS**

3889 **Operational Measures**

3890 Visual impacts from management of reservoir elevation at Dworshak would be no different
3891 than those described for the No Action Alternative.

3892 **Structural Measures**

3893 Removal of earthen embankments and some associated project infrastructure at the four lower
3894 Snake River projects would noticeably alter the viewshed at the four lower Snake River projects,
3895 and downriver from each project to the confluence of the Snake River with the Columbia River.
3896 The loss of the wide reservoirs would permanently expose portions of shoreline or reservoir
3897 bottom leading to temporary dust effects, erosion susceptibility, and rendering previous
3898 shoreline recreational facilities obsolete. Over time, the bare shoreline may revegetate and
3899 subsequently decrease the potential for erosion (Corps 2002b). These changes would alter that
3900 line, form, color, and texture within the existing viewshed and would result in a high degree of

3901 change. There would be a major visual quality impact that would diminish as the shoreline
3902 revegetates and blends into the surrounding landscape. With breaching of the lower Snake
3903 River projects, increases in road and rail transportation and the possible need for new
3904 infrastructure (see Section 3.10) to compensate for a reduction in river transportation would
3905 increase the level of change and could affect the visual quality.

3906 The impacts to viewers would vary dramatically based on viewer expectations, preference, and
3907 connection to the area. The degree of this impact is directly related to their sensitivity. The loss
3908 of earthen embankments and some project infrastructure may increase visual quality of the
3909 area for some sensitive viewers along the lower Snake River and counterbalance the loss of the
3910 lake-like viewshed. These viewers could be enriched by the return of the lower Snake River to a
3911 free-flowing riverine ecosystem. The cultural and spiritual attributes of a free-flowing river
3912 would be a positive outcome for tribes and others who value these attributes. The loss of
3913 reservoir attributes would likely have an adverse effect on the quality of the landscape for
3914 other viewer groups, such as residents and occupational viewers who associate the reservoirs
3915 with the identity of the area, as in the Lewiston area where loss of port capability could also
3916 occur (Corps 2002b).

3917 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3918 **Operational Measures**

3919 Visual impacts from management of increased spring spill would be negligible compared to
3920 those described for the No Action Alternative.

3921 **Structural Measures**

3922 Modification of project passage facilities such as upgrades to spillway weirs, modifications to
3923 fish ladders, and installation of passage routes would create a low degree of change by
3924 retaining the existing line, form, color, and texture. The effects related to these activities would
3925 be minor and short term. While new structures could result in moderate changes to the existing
3926 viewshed, visual quality impacts would generally be minor with a similar level of effect on the
3927 casual observer in the vicinity of those construction activities.

3928 **SUMMARY OF EFFECTS**

3929 Overall, the operational measures under MO3 would have a similar effect on the viewshed and
3930 to viewers as under the No Action Alternative, and the overall effect would be minor.

3931 For the structural measures, there would be major alterations to the viewshed associated with
3932 the dam breaching at the four lower Snake River projects and the associated changes to the
3933 landscape in Region C. Viewers would see substantial changes to the landscape in the vicinity of
3934 the lower Snake River projects with the loss of earthen embankments and some associated
3935 project infrastructure. There would be a loss of lake-like characteristics in the lower Snake River
3936 with the addition of the free-flowing river characteristics. Overall, the visual effect of dam
3937 breaching would be major. Depending on the viewer's perspective, this change could be
3938 beneficial or negative. All other structural measures would have a minor overall impact.

3939 **3.13.3.5 Multiple Objective Alternative 4**

3940 Changes to reservoir elevation from operational changes at storage projects would affect the
3941 viewshed and viewers in much the same manner as the No Action Alternative would.

3942 Operational measures in MO4, notably the *McNary Flow Target* measure, may have a minor,
3943 short-term effect on visual quality during the summer during drier-than-normal years resulting
3944 in Lake Koochanusa, Hungry Horse Reservoir, Lake Pend Oreille, and Lake Roosevelt having
3945 decreasing water levels. These drawdowns would result in a moderate degree of change to the
3946 existing viewshed, resulting in a moderate impact to visual quality. This would occur when
3947 recreational use is high, resulting in a greater exposure of sensitive viewers to the associated
3948 changes in visual qualities (see Figures 3-75, 3-79, 3-83, and 3-89). Structural changes for MO4
3949 include structural changes to projects and infrastructure necessary for maintenance and
3950 specific modifications to lower Columbia and lower Snake River projects for fish passage.
3951 The visual impacts would be short term during construction or maintenance activities and
3952 would result in a minor visual effect on viewers in the immediate vicinity of the project.

3953 **REGIONS A AND B – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS; GRAND COULEE AND**
3954 **CHIEF JOSEPH DAMS**

3955 **Operational Measures**

3956 The *McNary Flow Target* measure drafts the storage projects in Region A and B for fish flows in
3957 the lower basin. These drawdowns would result in a moderate degree of change from the
3958 existing viewshed, resulting in a short-term moderate effect on visual quality during the late
3959 summer during drier-than-normal years. This would occur when recreational use is high,
3960 resulting in a greater exposure of sensitive viewers to the associated changes in visual qualities
3961 (see Figures 3-75, 3-79, and 3-83). For this reason, there would be moderate effects on
3962 sensitive viewers.

3963 **Structural Measures**

3964 Modification of project passage facilities such as upgrades to spillway weirs, modifications to
3965 fish ladders, and installation of passage routes would create a low degree of change by
3966 retaining the existing line, form, color, and texture. The impacts related to these activities
3967 would be minor and short term. While new structures could result in moderate changes to the
3968 existing viewshed, visual quality impacts would generally be minor with a similar level of effect
3969 on the casual observer in the vicinity of those construction activities.

3970 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
3971 **HARBOR DAMS**

3972 **Operational Measures**

3973 Reservoir drawdown to minimum operating pool would result in lower Snake River projects
3974 operating at lower elevations during a portion of the year (see Section 2.3.6.1). The casual
3975 observer would be unlikely to notice the change compared to changes in elevation that occur
3976 annually as described under the No Action Alternative.

3977 **Structural Measures**

3978 Structural changes to projects and infrastructure maintenance would result in visual impacts
3979 similar to those described for Region A.

3980 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

3981 **Operational Measures**

3982 Reservoir drawdown to minimum operating pool would result in lower Columbia River projects
3983 operating at lower elevations during a portion of the year (see Section 2.3.6.1). The casual
3984 observer would be unlikely to notice the change compared to changes in elevation that occur
3985 annually as described under the No Action Alternative.

3986 **Structural Measures**

3987 Structural changes to projects and infrastructure maintenance would result in visual impacts
3988 similar to those described for Region A.

3989 **SUMMARY OF EFFECTS**

3990 Overall, the operational measures under MO4 would have an increased effect on visual quality
3991 and all viewer groups compared to the No Action Alternative. During summer months, there
3992 may be a major effect on the viewshed from lower reservoir levels at Lake Koochanusa, Hungry
3993 Horse Reservoir, Lake Pend Oreille, and Lake Roosevelt with corresponding effects experienced
3994 by all viewer groups. There would be a moderate effect on visual quality from new fish passage
3995 structures and a minor effect from modifications to fish ladders and changes to spillway weirs
3996 at the lower Columbia River projects in Region D and lower Snake River projects in Region C.

3997 **3.14 NOISE**

3998 **3.14.1 Introduction and Background**

3999 Noise is unwanted sound that disrupts normal activities or diminishes the quality of the
4000 environment for humans and other sensitive receptors. Depending on the intensity and level of
4001 exposure, excessive noise could lead to a range of effects: disrupted sleeping, difficulty
4002 communicating, changes in behavior, increases in stress levels, and physical injury (EPA 1978).
4003 At sound levels below those that cause physiological effects noise can reduce the aesthetic
4004 quality of the environment, especially in natural settings enjoyed by recreationalists, and may
4005 affect resource integrity for tribal members engaging in cultural activities or practices. This
4006 section evaluates potential noise effects to receptors such as humans, fish, and wildlife.

4007 **3.14.1.1 Area of Analysis**

4008 The analysis area for sound effects centers on each CRS dam and reservoir project site and
4009 follows a radius extending out to 3 miles. At this distance, sound levels normally diminish due
4010 to attenuation—by 50 decibels on the A-weighted scale (dBA)—rendering almost all sounds
4011 from project sites indistinguishable from background or ambient conditions. Effects outside this
4012 analysis area may occur with substantial changes in transportation methods. For example, if
4013 barge traffic decreases, truck and train transport may increase, which would increase noise
4014 levels along certain roads and rail routes.

4015 **3.14.2 Affected Environment**

4016 Noise traveling through air is usually expressed in decibels on the A-weighted scale, which is
4017 weighted to account for how humans hear sound. Table 3-284 provides typical noise levels in
4018 dBA from common sources. Noise exposure depends on the amount of time an individual
4019 spends near the source and distance from the source. To account for fluctuating sound levels,
4020 statistical descriptors have been developed for environmental noise. Exceedance levels
4021 (L levels) refer to the A-weighted sound level that is exceeded for a specified percentage of the
4022 time during a specified period. Thus, L₁₀ refers to a particular sound level that is exceeded
4023 10 percent of the time.

4024 **Table 3-284. Common Noise Levels**

Noise Source or Effect	Sound Level (dBA)
Night club with music	110
Pile driver	95–101
Concrete saw	90
Urban area, adjacent to freeway	88
Construction equipment, pneumatic tools	80–85
High-density urban areas	78
Urban areas	60–65
Normal conversation indoors	60
Suburban/residential areas	45–50
Rural areas	35–40

4025 Source: Cavanaugh and Tocci (1998); EPA (1978); Federal Highway Administration (2006); Washington Department
4026 of Transportation (2018)

4027 The Noise Control Act of 1972 (42 USC § 4901 et seq.), as amended, sets forth a broad goal of
4028 protecting all people from noise that jeopardizes their health or welfare. The Act further states
4029 that Federal agencies are authorized and directed, to the fullest extent consistent with their
4030 authority under Federal laws administered by them, to carry out the programs within their
4031 control in such a manner as to further this policy. Some states regulate noise by specifying
4032 allowable noise levels; although Federal agencies are not required to follow these state
4033 regulations, they provide useful benchmarks for analysis. The Washington Administrative Code
4034 (WAC 173-60) and the Oregon Administrative Rules (OAR 340-035) specify noise limits
4035 according to the type of property where the noise would be heard (the “receiving property”).¹
4036 Hydroelectric dams are classified as industrial sources for purposes of establishing allowable
4037 noise levels at the receiving property. Washington limits maximum-permissible-average-noise
4038 levels from industrial sources to 60 dBA (daytime) and 50 dBA (night) at a residential property
4039 or recreation facility such as a park or campground (WAC 173-60); louder sound levels are
4040 allowed for short durations depending on the dBA level. Oregon allows an L₅₀ noise level of
4041 55 dBA in daytime and 50 dBA at night and L₁₀ of 60/55dBA day/night (OAR 340-035). Under
4042 the Washington and Oregon regulations, daytime construction noises are usually exempt during
4043 the day.

4044 Ambient noise levels vary widely among the project sites depending on the surrounding land
4045 use and topography. Table 3-284 provides typical sound levels found in different settings.

4046 More rural CRS project sites such as Hungry Horse, Libby, Dworshak, Lower Granite, Little
4047 Goose, Lower Monumental, and John Day likely have ambient sound levels within the analysis
4048 area in the range of 35 to 40 dBA, especially at night, which are typical of rural settings (EPA
4049 1978). In each of these areas, the project itself may be a major local sound source through
4050 spillway noise, operation of the locks, substations and transformers, and maintenance
4051 operations. Although sound levels can be very high near operating turbines inside the
4052 powerhouse, this sound is usually substantially attenuated by the concrete superstructure of
4053 the project. Other major sound sources in these areas are nearby roads and railroads,
4054 agricultural or timber harvesting activities, recreational or commercial boat traffic, and wind.

4055 Several CRS project sites such as Albeni Falls, Grand Coulee, Chief Joseph, McNary, The Dalles,
4056 and Bonneville are near towns or populated areas. Ambient sound levels near these projects in
4057 closer proximity to more populated areas are likely higher than near the more rural projects
4058 described above because of increased vehicular traffic, commercial activities, and residential
4059 property maintenance activities, in addition to project operations.

4060 The distance to the nearest people who may experience noise effects at either a residential or
4061 recreational site ranges from 2.41 miles at Lower Monumental Dam to 0.24 mile at Albeni Falls
4062 Dam. The decrease in sound levels due to attenuation in relation to the nearest residence or
4063 recreational site at all the project sites averages approximately 36.5 dBA. People who are near
4064 the site for shorter periods, such as workers, fisherman and hunters, and tribal members
4065 engaging in cultural activities or exercising treaty rights may be closer to the project sites and

¹ Idaho and Montana do not have statewide noise regulations.

4066 could experience higher sound levels. Wildlife also could be much closer to any of the project
4067 sites, and therefore could experience higher sound levels. Underwater sound is also part of the
4068 ambient environment for fish and for wildlife such as diving birds and semi-aquatic animals
4069 such as beaver and muskrat. Primary contributors within the project area include operation of
4070 the spillways and locks and some maintenance at the project sites, as well as operation of
4071 boats, barges, grain terminals, and other shore-based industrial activities.

4072 **3.14.3 Environmental Consequences**

4073 **3.14.3.1 No Action Alternative**

4074 Under the No Action Alternative, all of the project sites in Regions A through D would continue
4075 existing operations and maintenance and associated sound levels. There are no anticipated
4076 noise effects in Canada as a result of the alternatives in this EIS.

4077 **OPERATIONAL MEASURES**

4078 Operation of the spillways, navigation locks, fishways, transformers, and turbines would
4079 continue to support flood risk management, irrigation, water supply, navigation, power
4080 production, recreation, and fish passage. The amount of water released through the spillway
4081 and the associated noise level at each project varies during the year, with generally higher
4082 sound levels during periods of high discharge and lowest during periods of low river discharge.
4083 At times, there may be no spillway-associated noise. Maximum spillway noise varies from year
4084 to year, depending on the level of spring runoff. Other sound sources such as transformers and
4085 turbines have sound levels that remain relatively constant during the year.

4086 **STRUCTURAL MEASURES**

4087 Periodic routine, non-routine, and unscheduled maintenance would continue to occur, and
4088 several previously planned structural modifications would occur as described in Section 2.3.2.
4089 Maintenance activities and previously planned structural changes could involve trucks, cranes,
4090 and pneumatic tools, which could temporarily increase ambient sound levels while the
4091 maintenance activity or modification is implemented. These actions could combine to create
4092 intermittent and temporary sound levels of over 90 dBA. The sites closest to people, such as
4093 Bonneville, Chief Joseph, Grand Coulee, McNary, and Albeni Falls Dams, could experience noise-
4094 level decreases of 28 to 33 dBA due to distance; these project sites could thus expose those
4095 individuals to temporary peak sound levels between 55 and 65 dBA. All these sites, however,
4096 are in relatively populated areas with likely daytime ambient sound levels between 50 and
4097 60 dBA, thus all but the loudest peak noises would be undetectable by the nearest residents
4098 and peak levels may be noticeable but would not likely cause annoyance. Sounds from these
4099 activities are currently part of the overall ambient soundscape in each project site vicinity.
4100 Wildlife closer to project sites may exhibit some startle reflexes or behavioral changes due to
4101 sounds from normal activities performed under the No Action Alternative. Underwater sound
4102 levels would continue to be similar to current levels.

4103 **SUMMARY OF EFFECTS**

4104 Noise associated with project operations would continue to occur, as would noise associated
4105 with periodic maintenance and planned structural modifications. Underwater sound levels
4106 would continue to be similar to current levels.

4107 **3.14.3.2 Multiple Objective Alternative 1**

4108 In addition to the operations and maintenance described for the No Action Alternative, MO1
4109 would include changes to the spill regime at a number of projects, and structural modifications
4110 at all of the lower Snake River and lower Columbia River projects.

4111 **OPERATIONAL MEASURES**

4112 The proposed operational changes may alter the timing of peak flows, but would not likely
4113 result in flow over spillways, through turbines, or fish passageways greater than existing peak
4114 flows experienced during annual periods of heavy runoff. Therefore, proposed operational
4115 measures would not change the potential magnitude of sound levels in the vicinity of any of the
4116 project sites for any region compared to the No Action Alternative, but could cause minor
4117 changes in the seasonal timing or duration of high-flow and high-spillway noise levels at any
4118 project.

4119 **STRUCTURAL MEASURES**

4120 No structural measures are proposed for the projects in Regions A or B other than maintenance
4121 actions as described in the No Action Alternative and the effects would not differ from those of
4122 the No Action Alternative.

4123 The proposed modifications to the lower Snake River and lower Columbia River projects in
4124 Regions C and D in MO1 would require temporary use of standard construction tools and
4125 equipment. This equipment could combine to produce peak sound levels of 90 dBA or more
4126 (at 50 feet) for short periods; therefore, peak sound levels experienced by nearby people could
4127 be approximately 65 dBA during the day. This may be noticeable, but would be temporary and
4128 would not be likely to cause annoyance to people in nearby residences or recreation areas.
4129 Wildlife nearer to the project sites would experience higher sound levels and could exhibit
4130 short-term behavioral responses; depending on the season, some wildlife may avoid foraging or
4131 nesting near a project while the structural modifications are performed. Some structural
4132 modifications could cause temporary increases in underwater sound levels, but these would
4133 likely be of shorter duration and much lower levels than those associated with pile driving, and
4134 depending on the location and timing of the modification, could be undetectable above the
4135 ambient operational project environment. The proposed structural measures would generally
4136 use similar equipment to some of the normal maintenance activities as described in the No
4137 Action Alternative.

4138 **SUMMARY OF EFFECTS**

4139 Overall, there would be a negligible to minor effect to noise levels from operational measures.
4140 The effect of the proposed MO1 structural measures on ambient sound levels at the lower
4141 Snake River projects in Region C and lower Columbia River projects in Region D would be similar
4142 to the No Action Alternative and would be a minor effect.

4143 **3.14.3.3 Multiple Objective Alternative 2**

4144 In addition to the operations and maintenance actions described for the No Action Alternative,
4145 MO2 would include changes to the spill regime at a number of projects, and structural
4146 modifications at all of the lower Snake River and lower Columbia River projects.

4147 **OPERATIONAL MEASURES**

4148 The proposed operational changes may alter the timing of peak flows, but would not likely
4149 result in flow over spillways, through turbines, or fish passageways greater than existing peak
4150 flows experienced during annual periods of heavy runoff. Therefore, proposed operational
4151 measures would not change the potential magnitude of sound levels in the vicinity of any of the
4152 project sites for any region compared to the No Action Alternative, but could cause minor
4153 changes in the seasonal timing or duration of high-flow and high-spillway noise levels at any
4154 project.

4155 **STRUCTURAL MEASURES**

4156 No structural measures are proposed for the projects in Regions A or B under MO2 other than
4157 maintenance actions as described in the No Action Alternative and the impacts would not differ
4158 from those of the No Action Alternative.

4159 The proposed modifications to the lower Snake River and lower Columbia River projects in
4160 Regions C and D in MO2 would require temporary use of standard construction tools and
4161 equipment. This equipment could combine to produce peak sound levels of 90 dBA or more
4162 (at 50 feet) for short periods; therefore, peak sound levels experienced by nearby people could
4163 be approximately 65 dBA during the day. This noise level may be noticeable, but would be
4164 temporary and would not be likely to cause annoyance to people in nearby residences or
4165 recreation areas. Wildlife nearer to the project sites would experience higher sound levels and
4166 could exhibit short-term behavioral responses; depending on the season, some wildlife may
4167 avoid foraging or nesting near a project while the structural modifications are performed. Some
4168 structural modifications could cause temporary increases in underwater sound levels, but these
4169 would likely be of shorter duration and much lower levels than those associated with pile
4170 driving, and depending on the location and timing of the modification, could be undetectable
4171 above the ambient operational project environment. The proposed structural measures would
4172 generally use similar equipment to some of the normal maintenance activities as described in
4173 the No Action Alternative.

4174 **SUMMARY OF EFFECTS**

4175 Overall, there would be a negligible to minor effect to noise levels from structural and
4176 operational measures under MO2.

4177 **3.14.3.4 Multiple Objective Alternative 3**

4178 In addition to the operations and maintenance described for the No Action Alternative, MO3
4179 would include changes to the spill regime at a number of projects, structural modifications at all
4180 of the lower Columbia River projects, and breaching of the four lower Snake River projects.

4181 **OPERATIONAL MEASURES**

4182 The proposed operational changes under MO3 at sites other than the four lower Snake River
4183 projects may alter the timing of peak flows, but would not likely result in flow over spillways,
4184 through turbines, or through fish passageways greater than existing peak flows experienced
4185 during annual periods of heavy runoff. Therefore, proposed operational measures at all sites
4186 other than the four lower Snake River projects would not change the potential magnitude of
4187 sound levels in the vicinity of any of the project sites compared to the No Action Alternative,
4188 but could cause minor changes in the seasonal timing or duration of high-flow and high-spillway
4189 noise levels.

4190 Breaching of the four lower Snake River projects in Region C would reduce the ambient sound
4191 levels at the project sites to lower levels than the No Action Alternative because operations or
4192 maintenance would cease at those project sites. Breaching of the lower Snake River projects
4193 would restore the free-flowing riverine soundscape along the Snake River between the
4194 Columbia River and Lewiston, Idaho.

4195 Because breaching of the lower Snake River projects would eliminate barge traffic, MO3 could
4196 increase noise levels associated with train and truck traffic in parts of the lower Columbia River
4197 Basin. It may also result in relocating barge-loading facilities, with associated increases in sound
4198 levels, to locations downstream on the Columbia River. Concurrently, eliminating barge traffic
4199 and barge-loading facilities combined with a likely decrease in recreational boating would
4200 further decrease the average sound levels both at and within the vicinity of the four lower
4201 Snake River projects.

4202 **STRUCTURAL MEASURES**

4203 No structural modifications are proposed at projects in Regions A or B, or at Dworshak in
4204 Region C other than general maintenance actions as described under the No Action Alternative.
4205 MO3 structural modifications proposed at the lower Columbia River projects in Region D would
4206 require temporary use of standard construction tools and equipment. This equipment could
4207 combine to produce peak sound levels of 90 dBA or more (at 50 feet) for short periods;
4208 therefore, peak sound levels experienced by nearby people could be approximately 65 dBA
4209 during the day. This noise level may be noticeable, but would be temporary and would not be

4210 likely to cause annoyance to people in nearby residences or recreation areas. Wildlife nearer to
4211 the project sites would experience higher sound levels and could exhibit short-term behavioral
4212 responses; depending on the season, some wildlife may avoid foraging or nesting near a project
4213 while the structural modifications are performed. Some structural modifications could cause
4214 temporary increases in underwater sound levels, but these would likely be of shorter duration
4215 and much lower levels than those associated with pile driving, and depending on the location
4216 and timing of the modification, could be undetectable above the ambient operational project
4217 environment. The proposed structural measures would generally use similar equipment to
4218 some of the normal maintenance activities as described in the No Action Alternative.

4219 MO3 calls for breaching of earthen embankments and other major structural changes to the
4220 four lower Snake River projects in Region C, which would require more construction equipment
4221 operating for long periods (at least during daylight hours for several months); this could result
4222 in average daytime sound levels over 95 dBA at the construction site, with peak sound levels
4223 over 100 dBA, especially if the breaching requires installing sheet piles. Little Goose and Lower
4224 Monumental are relatively isolated—they lack residences for at least 1.76 miles. Thus, people
4225 near these two sites would likely hear only the loudest peak sounds. There is one residence
4226 approximately 0.6 mile from Lower Granite, but otherwise the project vicinity is sparsely
4227 populated. The one residence is separated topographically from the project by a ridge, so
4228 sound levels could be less than predicted based on straight line attenuation, but daytime sound
4229 levels could be over 60 dBA. There are numerous residences near Ice Harbor, some as close as
4230 0.5 mile. Average daytime sound levels at these residences could be greater than 60 dBA, and
4231 thus higher than the limits described in WAC 173-60. Peak sound levels could be greater than
4232 70 dBA. Wildlife could be located closer to the sound sources, and thus could be exposed to
4233 higher sound levels that may affect behavior such as nesting or foraging.

4234 Underwater sound levels would increase during earthen embankment breaching and
4235 subsequent levee construction around the remaining project structures, modifications of the
4236 structures to allow for full drawdown, and possible cofferdam installation to facilitate work.
4237 Limited information is available on underwater construction sound except for pile driving,
4238 which could be used to install cofferdams. The type of piles and estimated number of strikes
4239 are currently unknown and are needed to estimate the sound levels resulting from installation
4240 of cofferdams at the projects. However, it is known that unmitigated single-strike peak-sound
4241 levels can vary from around 177 dB to over 210 dB or more depending on the pile material and
4242 size, and many projects have measured cumulative sound exposure level (cSEL) values of 166 to
4243 210 dB (WSDOT 2018). Thus, pile driving to install cofferdams could cause sound levels that
4244 injure fish (i.e., greater than 206 dB peak or 183 dB cSEL) or cause behavioral responses if
4245 appropriate mitigation is not implemented (Fisheries Hydroacoustic Working Group 2008).
4246 There are various ways to mitigate pile driving noise that can substantially reduce peak and
4247 cSEL levels such as vibratory hammers and bubble curtains (WSDOT 2018).

4248 **SUMMARY OF EFFECTS**

4249 In Regions A, B, and D, and at Dworshak in Region C, the proposed MO3 operational and
4250 structural measures are likely to be similar to the No Action Alternative and would result in
4251 negligible to minor noise effects.

4252 In Region C, breaching of the four lower Snake River dams would result in temporary noise from
4253 construction activities. This noise could temporarily exceed state noise standard levels at
4254 nearby residences. Overall, construction noise related to dam breaching would result in
4255 moderate noise effects, particularly for nearby residents. However, once beaching work is
4256 completed, the local noise levels would be lower than under the No Action Alternative because
4257 operations and maintenance would cease at those project sites. In the long term, increased rail
4258 and vehicle traffic would likely result in a minor change to noise levels.

4259 **3.14.3.5 Multiple Objective Alternative 4**

4260 In addition to the operations and maintenance described for the No Action Alternative, MO4
4261 would include changes to the spill regime at a number of projects, and structural modifications
4262 at all of the Snake River and lower Columbia River projects.

4263 **OPERATIONAL MEASURES**

4264 The proposed operational changes may alter the timing of peak flows, but would not likely
4265 result in flow over spillways, through turbines, or through fish passageways greater than
4266 existing peak flows experienced during annual periods of heavy runoff. Therefore, proposed
4267 operational measures would not change the potential magnitude of sound levels in the vicinity
4268 of any of the project sites for any region compared to the No Action Alternative, but could
4269 cause minor changes in the seasonal timing or duration of high-flow and high-spillway noise
4270 levels at any project.

4271 **STRUCTURAL MEASURES**

4272 No structural measures are proposed for the projects in Regions A or B under MO4 other than
4273 maintenance actions as described in the No Action Alternative and the impacts would not differ
4274 from those of the No Action Alternative.

4275 The proposed modifications to the lower Snake River and lower Columbia River projects in
4276 Regions C and D in MO4 would require temporary use of standard construction tools and
4277 equipment. This equipment could combine to produce peak sound levels of 90 dBA or more
4278 (at 50 feet) for short periods; therefore, peak sound levels experienced by nearby people could
4279 be approximately 65 dBA during the day. This noise level may be noticeable, but would be
4280 temporary and would not be likely to cause annoyance to people in nearby residences or
4281 recreation areas. Wildlife nearer to the project sites would experience higher sound levels and
4282 could exhibit short-term behavioral responses; depending on the season, some wildlife may
4283 avoid foraging or nesting near a project while the structural modifications are performed. Some

4284 structural modifications could cause temporary increases in underwater sound levels, but these
4285 would likely be of shorter duration and much lower levels than those associated with pile
4286 driving, and depending on the location and timing of the modification, could be undetectable
4287 above the ambient operational project environment. The proposed structural measures would
4288 generally use similar equipment to some of the normal maintenance activities as described in
4289 the No Action Alternative.

4290 **SUMMARY OF EFFECTS**

4291 Overall, there would be a negligible to minor effect to noise levels from structural and
4292 operational measures under MO4.

4293 **3.15 FISHERIES AND PASSIVE USE**

4294 **3.15.1 Introduction and Background**

4295 This section considers the social and economic values related to fish, and how they may be
4296 affected by the CRSO alternatives. The effects of the CRSO alternatives on potentially affected
4297 fish species are presented in Section 3.5. This section references those results in addressing
4298 how the commercial and ceremonial and subsistence fisheries that depend upon those fish
4299 species may be affected by the alternatives. The potential impacts to recreational fisheries are
4300 described in the Recreation/Environmental Consequences section.

4301 **3.15.2 Affected Environment**

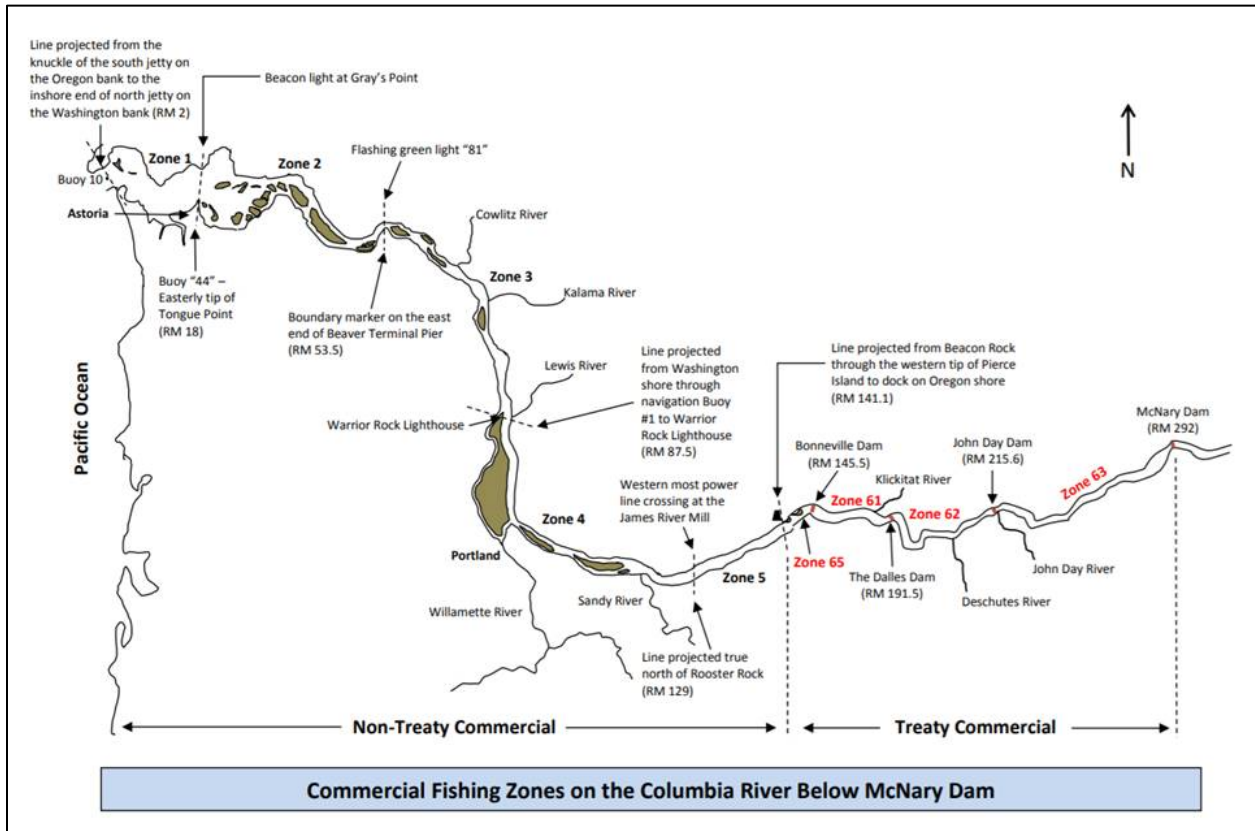
4302 **3.15.2.1 Columbia River Basin-Origin Fisheries**

4303 “Fisheries” are generally defined as a group of individuals or vessels that catch finfish or harvest
4304 shellfish, with specific commonalities in activity, including the fish species or stock targeted, the
4305 gear used, the location of activity, and the season of activity. The fish resources of the Columbia
4306 River Basin are caught in commercial, recreational, and tribal ceremonial and subsistence
4307 fisheries both within the Basin and in the ocean off the coasts of Washington, Oregon,
4308 California, British Columbia, and Alaska. Fish are a resource of critical importance to the tribes
4309 of the region. Every tribe in the Columbia River basin that signed a treaty with the United States
4310 reserved the right to harvest fish, and these rights were a critical component to those treaty
4311 negotiations. The Federal government has a trust responsibility to all federally-recognized
4312 tribes, which includes protection of treaty-reserved rights and tribal resources.

4313 Commercial fisheries refer to fishing and catch, either in whole or in part, intended for
4314 commerce through documented sale, barter, or trade through licensed fish dealers.
4315 Commercial fishing for Columbia River Basin-origin fish is conducted by both tribes and the non-
4316 tribal public. The majority of commercial fishing in the Columbia River Basin generally occurs in
4317 the main stem of the Columbia River between the mouth of the river and just upstream of
4318 McNary Dam. Salmonid species, Chinook salmon and coho salmon specifically, dominate
4319 commercial catch of Columbia River Basin-origin fish both within the Columbia River and in
4320 Pacific Ocean fisheries. Commercial salmonid catch within the Columbia River Basin includes
4321 Chinook salmon, coho salmon, sockeye salmon, and steelhead. Other anadromous fish,
4322 including certain white sturgeon populations, American shad, and Pacific eulachon, are also
4323 caught commercially in the Columbia River Basin. Resident (non-anadromous) fish are not
4324 targeted in the Basin commercially, though some are caught incidentally and sold in tribal
4325 fisheries.

4326 Tribal ceremonial and subsistence fishing is an important cultural, economic, and spiritual
4327 practice for American Indian tribes and Canadian First Nations in the Columbia River Basin.
4328 Salmon, in particular, are of critical importance to the spiritual and cultural identify of many of
4329 the region’s tribes. Tribal ceremonial and subsistence fishing includes treaty-reserved catch by
4330 tribal members for ceremonial purposes, personal, familial, and community consumption, or

4331 sale of subsistence catch. Tribes in the region rely upon salmon for a variety of purposes.
4332 Salmon play a key role in numerous ceremonies of importance to regional tribes, including the
4333 first salmon ceremony, naming ceremonies, giveaways and feasts, and funerals. Beyond the
4334 cultural value provided by traditional uses of salmon, and the economic value associated with
4335 providing a low-cost source of protein, salmon is considered to provide an important health
4336 benefit to tribal members. Additionally, the use of salmon for these traditional purposes serves
4337 to facilitate the transfer of knowledge and culture across generations. As such, changes in the
4338 amount or quality of fish caught in tribal ceremonial and subsistence fisheries would result in
4339 social, cultural, and economic impacts that are unique to tribes, and distinct from impacts to
4340 non-tribal populations and communities (Figure 3-222).



4341 **Figure 3-222. Commercial Fishing Zones on the Columbia River below McNary Dam**
4342 Source: ODFW (2018)
4343

4344 Recreational fisheries are inclusive of people who fish for sport or pleasure and charter vessels
4345 that provide a for-hire recreational fishing experience. Recreational fishery catch may be
4346 released or retained for personal consumption, but is not sold for profit. Columbia River Basin-
4347 origin fish support in-river, reservoir, and lake recreational fisheries in addition to supporting
4348 ocean fishery recreation. People fish by boat and from the shore, targeting anadromous species
4349 such as Chinook salmon, coho salmon, sockeye salmon, steelhead, shad, sturgeon, and
4350 eulachon. Cold water fishing for kokanee salmon and rainbow trout is popular in reservoirs and
4351 tributaries to the Columbia River mainstem, and fishing for resident species including suckers,

4352 pike, burbot, catfish, bass, sunfish, walleye, and perch is also popular. Recreational fisheries are
4353 discussed in detail in [Recreation/Affected Environment].

4354 **MANAGEMENT OF COLUMBIA RIVER BASIN-ORIGIN FISHERIES**

4355 Fisheries in the Columbia River Basin and those that rely upon Columbia River fish stocks are
4356 managed by numerous entities, including Federal, state, and tribal governments.¹ These
4357 entities are guided by a complex array of policies, laws, compacts, and agreements. The
4358 management of Pacific salmon fisheries in particular is complex, and involves numerous entities
4359 representing a variety of social, political, and conservation interests. Changes in allowable
4360 fishery harvest in the Columbia River Basin are a result of decisions made by state, Federal (i.e.,
4361 NMFS), and tribal fishery managers based on a variety of environmental, biological, economic,
4362 and social factors.

4363 The primary basis for fisheries management in the Columbia River Basin is *United States v.*
4364 *Oregon*, the ongoing Federal court proceeding first brought in 1968, *Sohappy v. Smith*, 302 F.
4365 Supp. 899 (D. Or. 1969), to enforce the reserved fishing rights of the Confederated Tribes of
4366 Warm Springs, Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, and
4367 the Confederated Tribes and Bands of the Yakama Nation. The 1969 decision ruled that state
4368 regulatory power over American Indian fishing is limited because treaties made in 1855
4369 between the United States and the tribes reserved the tribes' exclusive rights to fish in waters
4370 running through their reservations and at "all usual and accustomed places in common with
4371 citizens of [Oregon] Territory" (NMFS 2018f). Salmon and steelhead fisheries in the Columbia
4372 River have subsequently been managed by NMFS and other state, tribal, and local entities
4373 subject to provisions of *United States v. Oregon* under the continuing jurisdiction of the Federal
4374 court.² The 2018-2027 *United States v. Oregon* Management Agreement provides the current
4375 framework for managing fisheries and hatchery programs in much of the Columbia River Basin
4376 (NMFS 2018f). Once allocation between non-tribal and tribal fisheries is determined, harvest
4377 and management of the tribal allocation is at the discretion of the individual tribes. The four
4378 tribes fish together in the main stem of the Columbia River with the common goal of achieving
4379 their collective allocation goal, but each tribe establishes its own regulations guiding
4380 participation of their own members in the fisheries. There are not set rules or guidelines
4381 dictating the distribution of the tribal allocation among commercial and ceremonial and
4382 subsistence catch, but tribes generally prioritize ceremonial and subsistence needs over tribal
4383 commercial harvest. In certain tributaries, individual tribes co-manage fishing activity with the
4384 state (e.g., fishing in the Klickitat River is co-managed by the State of Washington and the
4385 Yakama Nation) (Ellis 2018).

¹ The three co-lead agencies (Corps, Reclamation, and Bonneville) do *not* manage fish stocks, and do not have the authority to do so.

² The *U.S. v Oregon* management agreement sets harvest policies for salmon and steelhead stocks returning to areas above Bonneville Dam. However, it does not set policies for lower river stocks, including lower Columbia River Chinook salmon, coho salmon, chum salmon, or steelhead, or Upper Willamette River spring Chinook salmon or steelhead (NMFS 2017).

4386 For ocean fisheries, the PFMC, one of eight regional fishery management councils established
4387 by the Magnuson-Stevens Fishery Conservation and Management Act of 1976 to manage
4388 offshore fisheries, proposes management strategies for salmon fisheries occurring in the United
4389 States Exclusive Economic Zone, defined as the area from 3 to 200 nautical miles offshore, for
4390 approval by NMFS, which is the Federal regulatory entity.³ The Pacific Coast Salmon Fishery
4391 Management Plan is the fishery management plan of the PFMC that covers commercial and
4392 recreational salmon fisheries off the coasts of Washington, Oregon, and California. The Pacific
4393 Coast Salmon Fishery Management Plan includes conservation measures, a framework for
4394 resource sharing, and strategies to ensure maintenance of sustainable salmon stocks (PFMC
4395 2018a). Chinook (king) salmon and coho (silver) salmon are the primary salmon species covered
4396 by this plan along with important populations of pink salmon (PFMC 2016). Each year, the
4397 PFMC goes through a preseason management process to develop annual salmon management
4398 recommendations based upon catch in the previous year and anticipated abundance in the
4399 coming year (PFMC 1999a). This management process requires approval by NMFS. Within their
4400 determined allocation, individual tribes with retained rights to fish for salmon on the outer
4401 coast of Washington manage their own fisheries. Although several tribes are important
4402 participants in commercial fishing on the outer coast of Washington, only limited ceremonial
4403 and subsistence fishing occurs there (PFMC 2019).

4404 The 1985 Pacific Salmon Treaty signed by the United States and Canada ensures
4405 conservation of fish populations and habitats and an equitable harvest of Pacific salmon and
4406 steelhead stocks among southeast Alaska, British Columbia, Washington, and Oregon.
4407 Sustainable fishing practices for optimal production and regulatory measures to avoid
4408 overfishing are key aspects of the treaty. Both the United States and Canada recognize that
4409 without regulation, each party would have an incentive to overfish. The treaty is therefore
4410 necessary to maintain salmon stocks and sustain fisheries over time (PFMC 1999). The
4411 Pacific Salmon Commission (PSC) was established to uphold the treaty and manage
4412 fisheries. The PSC is an international decision-making organization, composed of four
4413 Commissioners from the United States and Canada. This body handles on-going
4414 administration of the Pacific Salmon Treaty through advice from regional experts. It has
4415 responsibility for all salmon originating in the waters of one country which are subject to
4416 interception by the other, which affect management of the other country's salmon or affect
4417 biologically the stocks of the other country. The PSC is also charged with accounting for the
4418 conservation of steelhead trout while fulfilling its other functions (PSC 2018). As it is not a
4419 regulatory body, the PSC sends the plans and recommendations to the United States and
4420 Canadian governments for approval and implementation (PSC 2018).

³ The Pacific Fishery Management Council (PFMC) is one of the eight regional fishery management councils established by the Magnuson-Stevens Fishery Conservation and Management Act for the management of federal fisheries

4421 **STATUS AND TRENDS OF FISHERIES FOR COLUMBIA RIVER BASIN-ORIGIN FISH**

4422 **Ceremonial and Subsistence Fisheries**

4423 Based on the treaties signed in 1855, four tribes have adjudicated treaty-based fishing rights to
4424 salmon in the Columbia River: Confederated Tribes and Bands of the Yakama Nation,
4425 Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm
4426 Springs Reservation of Oregon, and the Nez Perce Tribe of Idaho. The Shoshone-Bannock tribe
4427 has asserted tribal fishing rights under another treaty, and the Colville and Spokane tribes have
4428 also asserted such rights (PFMC 1999a). Ceremonial and subsistence fishing for other species of
4429 anadromous and resident fish is conducted by these and other tribes and Canadian First
4430 Nations throughout the basin.

4431 Ceremonial and subsistence fisheries in the Columbia River Basin occur throughout the year
4432 (NMFS 2014). The number of fish allocated to ceremonial and subsistence fisheries and the gear
4433 used in this type of fishing are regulated by the tribes; the Columbia River treaty tribes have
4434 authority to regulate ceremonial and subsistence fishing by their tribal members (PFMC 1999a).
4435 Harvest of salmon for ceremonial and subsistence purposes occurs both in the mainstem and
4436 tributary areas of the mid-Columbia River, upper Columbia River, and lower Snake River
4437 regions. Subsistence fish are generally taken with dipnets, hoopnets, setnets, and hook-and-line
4438 gear from platforms primarily in the areas below The Dalles at Lone Pine and above Bonneville
4439 in the Cascade Locks area. Spears and gaffs are also used in specific tributary areas (PFMC
4440 1999a). Ceremonial and subsistence harvest typically is focused on spring Chinook salmon;
4441 however, it can include coho salmon, steelhead, and summer and fall Chinook salmon (NMFS
4442 2014). Some tribes in the Basin have lost access to ceremonial and subsistence fishing in usual
4443 and accustomed places due to extirpation of anadromous fish populations, including extirpation
4444 above federal dams in the Columbia River basin which were constructed without fish passage
4445 (Chief Joseph, Grand Coulee, and Dworshak Dams).

4446 No comprehensive data exist for tracking past ceremonial and subsistence harvest in the
4447 Columbia River. Estimates developed for the 2014 Mitchell Act EIS concluded that subsistence
4448 catch from both the mainstem and terminal areas of the mid-Columbia River were, at
4449 minimum, 19,360 fish annually, of which 92 percent were Chinook salmon. In the upper
4450 Columbia River, ceremonial and subsistence catch was estimated to be approximately 3,000
4451 fish annually, while at least 6,000 fish were estimated to be harvested annually in the lower
4452 Snake River (NMFS 2014).

4453 The Yakama Nation continues to rely critically upon salmon and steelhead fishing for its way of
4454 life. Ceremonial and subsistence fishing occurs year-round on the Columbia River, and from April
4455 through October on its tributaries (Yakama Nation 1998 and Parker 1999, as cited in NMFS
4456 2003). In addition to fishing in Zone 6 of the Columbia River, the Yakama Nation (along with
4457 other treaty tribes) maintains a right to conduct subsistence fisheries below Bonneville Dam,
4458 including on the Willamette River. Yakama Nation tribal members also conduct ceremonial and
4459 subsistence fisheries on the Yakima River, Klickitat River, Wind River, and Icicle Creek (a tributary
4460 of the Wenatchee River), as well as on the Little White Salmon, White Salmon, Wenatchee,

4461 Entiat, Methow, and Okanogan rivers (Yakama Nation 1998 as cited in NMFS 2003). Tribal
4462 members typically employ long-handed hoopnet gear from platforms over the river, though
4463 hook and line fishing has been increasing in popularity below the John Day and The Dalles dams.
4464 Gillnets may occasionally be used with agreement by the states when large quantities of fish are
4465 required for ceremonial purposes. Spring Chinook salmon are the most highly-valued species for
4466 cultural purposes (Yakama Nation 1998 as cited in NMFS 2003).

4467 Salmon and steelhead fishing continue to be of utmost importance to the Confederated Tribes
4468 of Warm Springs. Several hundred tribal members conduct ceremonial and subsistence fishing
4469 from March through October, with an intensive period for four to six weeks within that window.
4470 These fisheries target spring, summer, and fall Chinook, sockeye salmon, and steelhead. Fishing
4471 occurs primarily in Zone 6 of the mainstem Columbia River, in the Deschutes River, and in the
4472 Willamette River, with some additional activity in the Hood and John Day Rivers (Fagen 1999 as
4473 cited in NMFS 2003).

4474 Salmon and steelhead fishing are the foundation of the Confederated Tribes of the Umatilla
4475 Indian Reservation's way of life. Tribal members place an emphasis on using traditional locations
4476 and gear to harvest fish. Approximately 100 tribal members participate in ceremonial and
4477 subsistence fishing, with a particular interest in harvest of spring Chinook salmon in the
4478 Columbia River. Other species targeted in these fisheries, which vary seasonally, include summer
4479 and fall Chinook salmon, coho salmon, sockeye salmon, and steelhead. Tribal members fish in
4480 Zone 6 of the mainstem Columbia River and its tributaries, including the Umatilla River, Grand
4481 Ronde River, Tucannon River, John Day River, and lower Yakima River (James 1999 as cited in
4482 NMFS 2003).

4483 The Nez Perce Tribe's culture, spiritual beliefs, economy, and way of life focus on salmon and
4484 steelhead. The Nez Perce Tribe conducts ceremonial and subsistence fisheries in Zone 6 of the
4485 Columbia River, as well as in much of the Snake River Basin (NMFS 2003). Some authors (Polissar
4486 et al. 2016) surmise that the tribe may have the largest number of tributary salmon and
4487 steelhead fisheries across Washington, Oregon, and Idaho, many of which occur year-round. The
4488 Tribe has usual and accustomed fishing places across 13 million acres identified as having been
4489 exclusively used and occupied by the tribes, including substantial portions of rivers including the
4490 Snake, Tucannon, Imnaha, Grand Ronde, Salmon, and Clearwater, as well as in the mainstem
4491 Columbia and elsewhere in the Columbia and Snake River basins. Harvest by Nez Perce tribal
4492 members includes Chinook salmon, coho salmon, sockeye salmon, dolly varden, cutthroat trout,
4493 brook trout, lake trout, rainbow trout, suckers, white fish, sturgeon, Northern pikeminnow,
4494 lampreys, and some shellfish (Polissar et al. 2016).

4495 The Shoshone-Bannock Tribe have historically fished for salmon in the Columbia River Basin.
4496 Although tribal members do not participate in commercial fishing in the Zone 6 commercial
4497 tribal fishery, they do fish in the Salmon River and Snake River in Idaho. The tribe has also
4498 expressed interest in continuing to develop fisheries in other parts of Oregon and Washington
4499 (NMFS 2014).

4500 Another important example of ceremonial and subsistence fishing in the upper basin is the
4501 Kootenai Tribe of Idaho (KTOI), who historically relied on fishing for subsistence. The Kootenai
4502 River itself is part of the Tribe's identity. Kootenai River white sturgeon are an important
4503 resource to the tribe, as are fish in Flathead Lake and areas along the Kootenai River. A recent
4504 report reviews available information regarding heritage fish consumption rates for the KTOI
4505 (Ridolfi 2016). While the reported heritage fish consumption estimates summarized in this
4506 report vary greatly, the cited ethnographic studies provide evidence of the importance of fish
4507 for subsistence and the culture of the Kootenai Tribe. The Kootenai Tribe operates the Sturgeon
4508 and Burbot Conservation Hatchery to reverse the decline of white sturgeon and burbot on the
4509 Kootenai River (Kootenai Tribe of Idaho 2018a). In addition, the Kalispel Tribe of Indians, who
4510 fish for subsistence in the Box Canyon Reservoir, harvest fish placed there from the Kalispel
4511 Tribal Hatchery. The Tribe rears juvenile largemouth bass at the hatchery (Kalispel Tribe 2018d).
4512 Fishing access permits and hunting permits for fishing and hunting on the Reservation are sold
4513 by the Natural Resource Department to non-members (Kalispel Natural Resource Department
4514 2018). The Confederated Salish and Kootenai Tribes, with regulatory authority over fishing on
4515 the Flathead Reservation, charge fees for fishing permits for non-members, and the Division of
4516 Fish, Wildlife, Recreation, and Conservation regulates fishing activity carefully due to concern
4517 for the declining numbers of bull trout and west slope cutthroat trout (Division of Fish, Wildlife,
4518 Recreation, and Conservation et al. 2017).

4519 Tribes report that overall catch of fish has declined dramatically from historical times, and they
4520 have lost a substantial portion of the salmon that were protected in treaties signed with the
4521 United States (Meyer 1999). The loss of salmon becomes more pronounced the further
4522 upstream one goes. For example, the Nez Perce report total tribal fishing harvest in the 1990s
4523 was approximately 160,000 pounds annually, which represents about 10 percent of estimated
4524 harvest during the mid-1800s (Meyer 1999). In the 1990s, the Confederated Tribes of the
4525 Umatilla Indian Reservation and the Confederated Tribes of the Warm Springs Reservation total
4526 tribal fishing harvest was approximately 77,000 pounds annually, which represents less than
4527 two percent of the two tribes' estimated harvest during the mid-1800s (Meyer 1999). Likewise,
4528 the Yakama Nation's total tribal fishing harvest was approximately 1.1 million pounds annually,
4529 which is estimated to represent about 20 percent of estimated harvest during the mid-1800s
4530 (Meyer 1999).

4531 **Columbia River Commercial Fisheries**

4532 The majority of commercial fishing in the Columbia River Basin occurs in the main stem of the
4533 Columbia River in six identified "zones" (see Figure 3-222) located between the mouth of the
4534 river and just upstream of McNary Dam.⁴ The commercial fisheries are divided into tribal and
4535 non-tribal components, with most tribal commercial fisheries occurring between Bonneville and
4536 McNary Dams, in Zone 6, and non-tribal commercial fisheries occurring below Bonneville Dam,

⁴ Certain limited tribal commercial fisheries are also conducted farther upstream of McNary Dam.

4537 in Zones 1 to 5.⁵ Commercial fisheries primarily target anadromous species such as Chinook
4538 salmon and coho salmon, and target resident species to a much more limited extent.⁶

4539 Commercial Chinook salmon landings of Columbia River Basin-origin fish averaged 4.8 million
4540 pounds annually in the Basin and 1.7 million pounds annually in the ocean between 2013 and
4541 2017, for a total annual average of 6.5 million pounds landed. The total annual average ex-
4542 vessel value during this period was \$22.1 million. Commercial coho salmon landings averaged
4543 0.8 million pounds annually, with an average annual ex-vessel value of \$1.1 million (2013
4544 through 2017). Commercial catch of Columbia River Basin-origin coho salmon was almost
4545 entirely from within the basin, with only negligible contributions from ocean catches.

4546 ***Salmonids***

4547 Commercial fishing for salmonid species has been an important economic activity in the
4548 Columbia River Basin for thousands of years. During their expedition on the Columbia River,
4549 Lewis and Clark noted that approximately 50 tons of dried salmon were prepared by tribes
4550 fishing at Celilo Falls for trade exchange to other tribes (NW Power and Conservation Council
4551 2019). The pace of commercialization and industrialization of fishing by non-tribal people
4552 accelerated throughout the 1800s. With the influx of European settlers and development of
4553 canning technologies, commercial fisheries developed rapidly (NMFS 2003). Despite spikes in
4554 activity in the 1980s and early 2000s, commercial salmon landings have generally trended
4555 downward since the 1930s (NMFS 2014) due to declines in salmon runs. Fishing pressure has
4556 been recognized among activities contributing to the decline in salmon runs in the Columbia
4557 River Basin and elsewhere (National Research Council [NRC] 1999).

4558 The ex-vessel prices received for commercial salmon caught in the Columbia River Basin vary
4559 substantially by species (e.g., Chinook salmon vs. coho salmon), race (e.g., spring vs. fall), and
4560 stock (e.g., tules vs. brights).^{7,8} In general, spring Chinook salmon have a higher commercial
4561 value per pound than other salmon species/stocks (Lothrop 2018).

⁵ For purposes of fishery management, a distinction is drawn between “treaty fisheries” (those tribal fisheries wherein rights to fish are specifically reserved and guaranteed through a treaty with the United States), and “non-treaty fisheries,” which may include harvest by non-tribal members, as well as by members of tribes that do not have a treaty-guaranteed right to fish resources. The majority of tribal commercial harvest is conducted by the previously-identified treaty tribes. For simplicity, we refer to “tribal fisheries” throughout this section, though note that harvest identified as “tribal” is limited to treaty tribal harvest, and harvest by non-treaty tribes is included within the “non-tribal” harvest figures.

⁶ Walleye and other non-native fish species (e.g., bass, catfish) that are caught incidental to tribal fisheries targeting anadromous fish may be sold. Sale of walleye and other non-food fish by non-tribal fishermen is otherwise prohibited by state regulation (NMFS 2014). Walleye is the only resident species sold in any volume. However, in 2017 reported treaty commercial catch of walleye totaled only 71 fish (ODFW 2018b).

⁷ As defined by the NMFS Fisheries Glossary, the term “ex-vessel” refers to activities that occur when a commercial fishing boat lands or unloads a catch. “Ex-vessel value” is the price received by a captain (at the point of landing) for the catch.

⁸ The term “stock” refers to a group of fish of the same species that live in the same geographic area and mix enough to breed with each other. The term “tule” refers to the fall return-timed component of lower Columbia River Chinook salmon, while “bright” refers to a late-fall-timed component (NMFS 2018).

4562 Figure 3-223 shows the annual value of commercial salmonid catches in the Columbia River
4563 Basin from 2007 to 2017, including both tribal and non-tribal harvest. The average annual value
4564 of coho salmon and Chinook salmon caught in the Columbia River Basin between 2013 and
4565 2017 was \$13.7 million based on an average annual landed weight of 5.6 million pounds.⁹ Fall
4566 Chinook salmon consistently made up the largest proportion of the commercial catch value,
4567 followed by spring Chinook salmon. Treaty commercial fishermen are allowed to sell fish direct
4568 to consumers as well as to wholesale dealers. Ex-vessel prices do not reflect the higher prices
4569 paid in direct-to-consumer sales.

4570 Commercial tribal fisheries primarily target Chinook salmon, coho salmon, sockeye salmon and
4571 steelhead. The largest proportion of the catch is composed of fall Chinook bright salmon, with a
4572 smaller proportion of spring Chinook salmon. Catch of coho salmon and fall Chinook tule
4573 salmon is minimal compared to other harvested species/stocks. Commercial non-tribal salmon
4574 fisheries target Chinook salmon and coho salmon; there is no permitted commercial non-tribal
4575 catch of steelhead, and sockeye salmon are not a primary target of these fisheries.

4576 The average annual value of tribal commercial salmon catch within Zone 6 of the Columbia
4577 River between 2013 and 2017 was \$8.2 million, based on an average annual landed weight of
4578 3.4 million pounds. Tribal commercial value data were only available for Chinook salmon and
4579 coho salmon and, even then, data are only for sales made to licensed fish buyers, not direct
4580 sales to the general public which may be substantial. It is noted that Tribes do not draw a
4581 distinct separation between catch for commercial purposes versus catch for ceremonial and
4582 subsistence purposes. As such, tribes do not typically track the exact quantities of fish sold for
4583 commercial purposes, and since they do not require that fish be sold through licensed fish
4584 dealers, available fish ticket data likely underreports the quantity and value of tribal
4585 commercial catch (Ellis 2018). Consequently, any valuation under-represents the total value of
4586 commercial sales made by tribal fisherman (PFMC 2018).

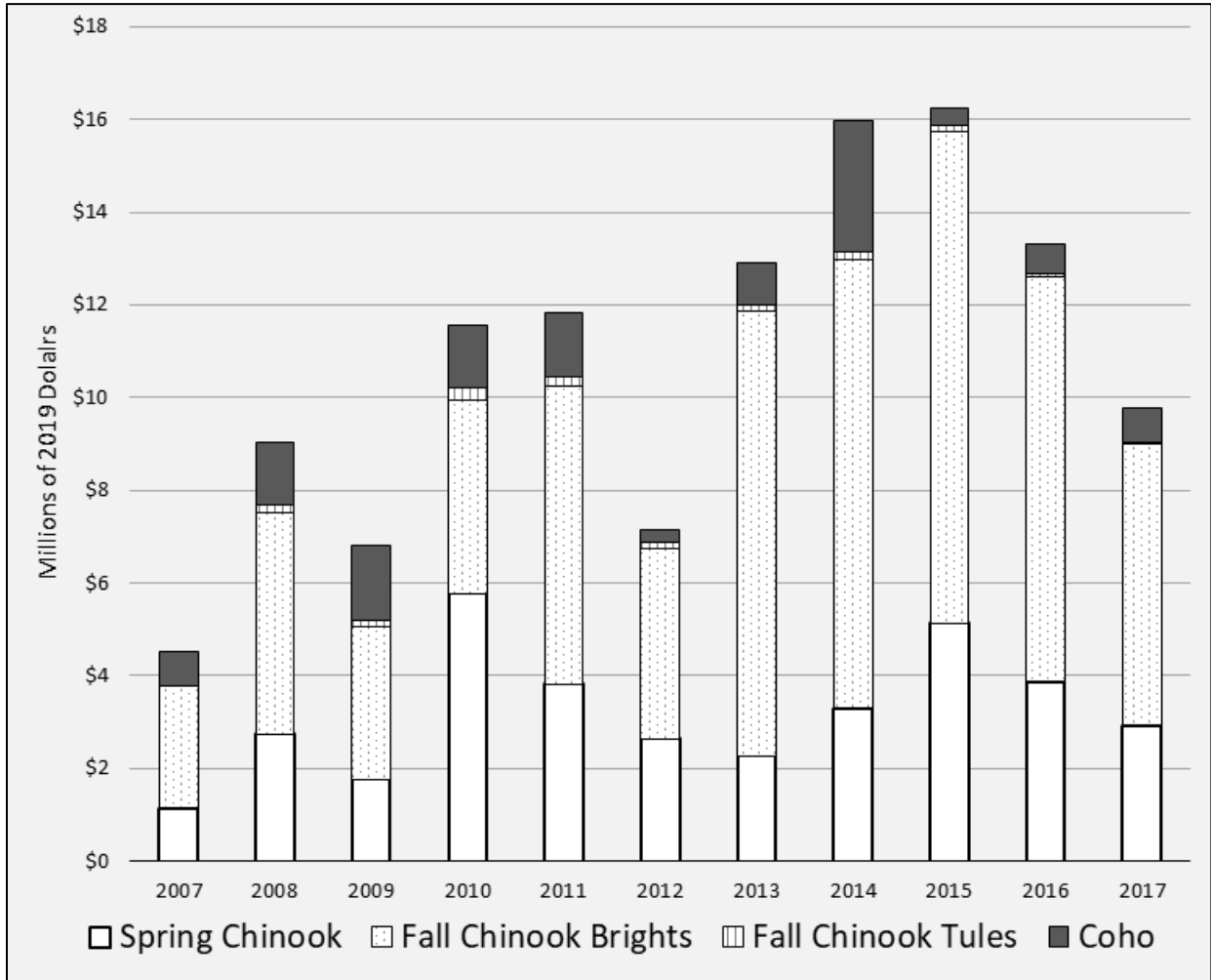
4587 The average annual value of non-tribal commercial salmon catch between 2013 and 2017 was
4588 \$5.4 million based on an average weight of 2.2 million pounds of fish harvested annually. Fall
4589 Chinook bright salmon generally account for the largest proportion of the non-tribal
4590 commercial catch, followed by spring Chinook salmon, with smaller proportions of fall Chinook
4591 tule salmon and coho salmon.

4592 Tribes do not issue commercial fishing permits or track participation in a comprehensive way,
4593 nor are data on participation readily available. Rather, tribal identification cards serve as fishing
4594 permits and any enrolled member can participate in any of the fisheries (Ellis 2018).
4595 Commercial non-tribal licenses to fish for salmonids in the Columbia River Basin are issued by
4596 the states of Washington and Oregon; there is no commercial fishing for anadromous species in
4597 Idaho.¹⁰ There are presently 287 Columbia River Commercial Gillnet Permits for the State of
4598 Oregon (Jones 2018). No new permits are available, though transfers are permitted under

⁹ Sale and possession of chum salmon has been prohibited since 2013, and any reported sales are likely due to mis-identification at landing (PFMC 2018). They are omitted from following tables and figures.

¹⁰ IDAPA 13.01.12 Rules Governing Commercial Fishing.

4599 certain circumstances (ODFW 2018a). In 2017, there were 247 Washington State permits for
 4600 commercial salmon fishing in the Columbia River (Vernie 2018).



4601 **Figure 3-223. Total Annual Value of Commercial Chinook Salmon and Coho Salmon Catch in**
 4602 **the Columbia River Basin by Stock, 2007–2017, Millions of 2019 dollars**
 4603

4604 Note: Value of tribal commercial catch accounted for in this figure includes only those sales made to licensed fish
 4605 dealers.¹¹

4606 Source: Authors’ calculations using data from PFMC (2018)

4607 **Other Anadromous Commercial Fisheries**

4608 In addition to salmonids, several other anadromous species are caught for commercial
 4609 purposes in the Columbia River Basin including certain white sturgeon populations and

¹¹ Since 1995, tribes have increasingly relied on direct sales to the public to maximize the value of their commercial catch. These sales are an important component of the total ex-vessel value derived from fisheries by treaty fishermen (NMFS 2003). Data on the total ex-vessel value of these sales are not well-documented or available, but anecdotal information suggests they may be substantial (Ellis 2018).

4610 American shad, and to a lesser extent, Pacific eulachon (also known as Pacific smelt or
4611 Columbia River smelt).^{12,13}

4612 • **White sturgeon** abundance downstream of Bonneville Dam has fluctuated greatly over the
4613 past few hundred years in response to human activity in the Columbia River Basin. In the
4614 late 1800s, the white sturgeon population dropped due to overfishing (ODFW/WDGW
4615 2018b). Management actions in the mid-1900s helped white sturgeon populations rebound,
4616 but in more recent years the population has declined, due to fishing and predation by sea
4617 lions. Fluctuations in fish numbers has prompted strict regulation of catch size, daily and
4618 annual catch, catch season, and gear type used to catch white sturgeon (ODFW/WDFW
4619 2018b). The Kootenai River population of white sturgeon is listed under the ESA and is not
4620 caught commercially.

4621 Commercial catch of sturgeon in Zone 6 has fallen steadily since 2001, but measured
4622 since 1996, catches have been cyclical as abundance has fluctuated (Sturgeon
4623 Management Task Force 2019; x). Gillnet, hook and line, and setline tribal commercial
4624 sturgeon fisheries occur in Zone 6, primarily in the winter. Between 2013 and 2017, the
4625 average tribal commercial landings of white sturgeon were 1,869 fish per year, although
4626 catch has steadily decreased from 2012 to 2017. In 2017, tribal sturgeon landings had an
4627 estimated ex-vessel value of \$99,000 for 906 fish (ODFW/WDFW 2018b).¹⁴ Non-tribal
4628 commercial catch was closed between 2014 and 2016 but was reopened in 2017. The
4629 total value of non-tribal commercial white sturgeon landings in 2017 was \$127,000, for
4630 1,227 fish.¹⁵ The average non-tribal landings for the two years for which the fishery was
4631 open during the last five years was 1,620 fish.

4632 • **American shad** Both tribal and non-tribal commercial fisheries target these fish during their
4633 return from the ocean, with runs extending from approximately mid-May through early
4634 August. Catch of the abundant runs of shad is regulated to minimize impacts to the
4635 overlapping runs of upriver Chinook salmon, sockeye salmon, and steelhead (ODFW/WDFW
4636 2018a).¹⁶

4637 Data quantifying tribal commercial catch of shad in the Columbia River Basin prior to
4638 2017 are not readily available. Fish not retained for subsistence are sold to commercial
4639 buyers or directly to the public. In 2017, 3,739 shad were sold by tribal fishermen to
4640 commercial buyers. Data for the total amount of retained shad and sales directly to the

¹² The sale of green sturgeon from Columbia River commercial fisheries has been prohibited since 2006 (ODFW/WDFW 2018b).

¹³ Although listed under the ESA, available harvest data indicate that some commercial sale of Pacific eulachon occurs.

¹⁴ Total pounds of treaty catch calculated based on pound per fish calculated from non-treaty catch values in ODFW/WDFW (2018b). Price per pound of sturgeon received in 2017 provided by WDFW by email on July 11, 2018. Price per pound of treaty white sturgeon used in this calculation is the average of winter, spring, and fall prices.

¹⁵ Total pounds of sturgeon non-treaty catch provided by ODFW/WDFW (2018a). Price per pound of sturgeon received in 2017 provided by WDFW by email on July 11, 2018.

¹⁶ ODFW/WDFW reports do not include commercial treaty harvest.

4641 public are generally not documented or are unavailable (Ellis 2018; ODFW/WDFW
4642 2018a).

4643 The non-tribal commercial shad fishery is small and limited to an area within Zones 4
4644 and 5 referred to as "Area 2S." Additional commercial shad harvest occurs via
4645 experimental gear permits, including beach and purse seine, outside of the Area 2S shad
4646 fishery. Between 2013 and 2017, average annual non-tribal commercial shad catch,
4647 inclusive of both the Area 2S and experimental gear fisheries, was 3,640 fish. Non-tribal
4648 commercial landings of shad in 2017 were amongst the lowest in almost 40 years, with
4649 only 2,007 shad landed. Non-tribal commercial catch of shad (again inclusive of the Area
4650 2S and experimental gear fisheries) peaked in 2012 with a catch of over 29,000 fish but
4651 has since remained low due to the low market value for this species (ODFW/WDFW
4652 2018a). In 2017, the price per pound of shad was only about \$0.05, making the total
4653 non-tribal value of shad landings in that year \$279.¹⁷

4654 • **Pacific eulachon** usually enter the Columbia River Basin around December and spawn
4655 February through April. Spawning occurs in the mainstem and in tributaries downstream of
4656 Bonneville Dam which is where these fish are harvested. In March of 2010, eulachon was
4657 added to the list of threatened species under the Endangered Species Act (ESA). Eulachon
4658 catch was regulated prior to 2010, but the ESA listing triggered a complete closure of all
4659 eulachon fishing in the Columbia River Basin from 2011-2013 (ODFW/WDFW 2018b).

4660 Eulachon catch has fluctuated dramatically over the last decade, with a high of 18,558
4661 pounds in 2014 and a three-year fishing closure resulting in a low of 0 pounds caught
4662 from 2011 to 2013. Almost all commercial catch of eulachon is non-tribal (ODFW/WDFW
4663 2018b). The value of the 5,019 pounds of non-tribal commercial eulachon landings in
4664 2017 was about \$7,800.¹⁸

4665 ***Pacific Ocean Commercial Fisheries***

4666 Anadromous fish originating from the Columbia River Basin contribute to recreational and
4667 commercial ocean fisheries in California, Oregon, Washington, British Columbia, and southeast
4668 Alaska. Columbia River Chinook salmon and coho salmon account for nearly 50 percent of the
4669 recreational harvest of those species, respectively, in northern Oregon and on the Washington
4670 coast. Columbia River Chinook salmon account for 22 percent of the recreational catch of that
4671 species in Southeast Alaska (NMFS 2014).¹⁹ Columbia-basin origin Chinook salmon and coho
4672 salmon also contribute substantially to commercial fisheries in Oregon, Washington, and
4673 Southeast Alaska, and to a lesser extent, in British Columbia (NMFS 2014). This section
4674 describes the United States commercial ocean fisheries to which Columbia River Basin fish
4675 contribute, including total ex-vessel values, landings, and participation in these fisheries. This

¹⁷ Price per pound of shad in 2017 provided by Lathrop (2018).

¹⁸ Ex-vessel value calculated based on price/pound information from Lathrop (2018).

¹⁹ Recreational catch of Columbia River Basin-origin Chinook salmon and coho salmon in British Columbia represents one percent or less of the overall recreational catch of these species in that region (NMFS 2014).

4676 section then presents an estimate of the amount of the identified catch that is attributable to
4677 Columbia River Basin-origin fish.

4678 Ocean Salmon Catch

4679 Commercial ocean salmon fisheries consist of a tribal and non-tribal component. The majority
4680 of the tribal ocean fishing activity for salmon on the west coast is for commercial purposes,
4681 although some is allocated for ceremonial and subsistence (PFMC 2018). Tribes with treaty
4682 rights to fish commercially in west coast ocean fisheries include the Makah Tribe, Quinault
4683 Indian Nation, Quileute Tribe, and Hoh Tribe (PFMC 2016). As noted previously, only very
4684 limited ceremonial and subsistence fishing occurs on the outer coast (PFMC 2019). Treaty
4685 ocean fisheries are not required to obtain fishing permits from the states or NMFS to troll off
4686 the coast, unlike non-treaty trollers (NMFS 2014). Tribal ocean salmon troll landings are more
4687 generally focused on Chinook salmon over coho salmon, although in some recent years (2012
4688 to 2014) landings of each were relatively similar and in 2009 more coho salmon were landed
4689 than Chinook salmon. The average annual landings of Chinook salmon and coho salmon
4690 between 2013 and 2017 was 70,621 fish.²⁰ The total value of tribal harvest of Chinook salmon
4691 and coho salmon has ranged from \$0.7 million to \$3.8 million annually between 2014 and 2017
4692 (PFMC 2018).

4693 Trolling is the only non-tribal commercial fishing method permitted in west coast fisheries (i.e.,
4694 Washington, Oregon, and California) and troll vessels must obtain permits from the states to fish
4695 for salmon (NMFS 2014). The number of licensed salmon vessels has declined substantially since
4696 the early 1980s through 1990s (PFMC 2018). In 2017, a total of 2,194 vessels were permitted to
4697 fish salmon commercially in the ocean fisheries off the coasts of Washington, Oregon, and
4698 California (155 in Washington, 955 in Oregon, 1,084 in California). Of those, 31 percent reported
4699 landing salmon in 2017 (PFMC 2018). In contrast to the west coast fisheries (Washington,
4700 Oregon, and California), salmon are harvested commercially under different regulations in
4701 Southeast Alaska using a variety of gear types including purse seines, drift gillnets, set gillnets,
4702 and with hand and power troll gear (Alaska Department of Fish and Game [ADFG] 2018b). The
4703 non-tribal commercial troll fishery has the highest number of permitted participants, with 830
4704 and 808 permits reporting landings of Chinook salmon and coho salmon, respectively in 2018, in
4705 Alaska (ADFG 2018c).

4706 Nearly all of the total ex-vessel value of the non-tribal commercial ocean troll salmon fishery in
4707 Washington and Oregon (including, but not limited to, stocks other than Columbia River Basin-
4708 origin) is Chinook salmon. The average annual ex-vessel value of Chinook salmon caught in the
4709 non-tribal commercial ocean troll Chinook salmon fishery in Washington and Oregon between
4710 2013 and 2017, including fish originating both within and outside of the Columbia River Basin,
4711 was \$10.5 million based an annual average landed weight of 1.6 million pounds (PFMC 2018).²¹
4712 Ex-vessel value of salmon catch (including non-Columbia River Basin-origin stocks) in southeast

²⁰ Landings are reported in the units reported by the source data to avoid the need for introduction of additional assumptions not made by the reporting agency required to convert between pounds and dollars and vice versa.

²¹ Includes non-Columbia River Basin-origin fish. Columbia River Basin-origin fish contribute approximately 32 percent of Chinook salmon landings in northern Oregon and Washington, 1 percent of coho salmon landings in northern Oregon and Washington, and about 11 percent of coho salmon landings in southern Oregon.

4713 Alaska is more evenly distributed between Chinook salmon and coho salmon.²² The average
4714 annual ex-vessel revenues for Chinook salmon and coho salmon between 2013 and 2017 was
4715 \$19.5 million and \$27.8 million, respectively (3.7 million pounds for Chinook salmon and 19.3
4716 million pounds for coho salmon). The total annual value of salmon landed in southeast Alaska is
4717 over eight times as large as the landings in the ocean troll fishery off Washington and Oregon.
4718 However, a large portion of those landings are fish that did not originate in the Columbia River
4719 Basin.

4720 Contribution of Columbia River Basin-Origin Fish to Commercial Ocean Fisheries

4721 As described previously, salmon originating from the Columbia River Basin migrate to the
4722 ocean, where they contribute to fisheries in southeast Alaska, British Columbia, Puget
4723 Sound/Strait of Juan de Fuca, and coastal areas of California, Oregon and Washington (NMFS
4724 2014). Fall Chinook salmon, summer Chinook salmon, and coho salmon are important
4725 components of these ocean fisheries. Other Columbia River Basin stocks do not contribute
4726 notably to these ocean fisheries (NMFS 2016). A number of sources provide estimates of the
4727 contributions of these Columbia River Basin stocks to ocean salmon fisheries, including NMFS
4728 (2016), Pacific Salmon Commission (PSC) (2018a), and 2014 Mitchell Act EIS (NMFS 2014).
4729 Because the NMFS (2016) and PSC (2018) estimates include both commercial and recreational
4730 fisheries and exclude contributions from coho salmon, our analysis relies on estimates from the
4731 2014 Mitchell Act EIS (NMFS 2014).

4732 The 2014 Mitchell Act EIS estimated the contribution of the Columbia River Basin-origin stocks of
4733 Chinook salmon and coho salmon specifically to commercial fisheries (NMFS 2014).²³ It
4734 estimated that Columbia River Basin-origin Chinook salmon composed 28 percent of commercial
4735 Chinook salmon catch in southeast Alaska, and 32 percent of commercial Chinook salmon catch
4736 off the Washington and Oregon coasts. That EIS also included estimates of Columbia River Basin-
4737 origin coho salmon in the commercial fisheries in southern Oregon and northern California of 11
4738 percent and in northern Oregon and Washington of 1 percent (NMFS 2014).

4739 Catch composition data for Columbia River Basin-origin stocks can be combined with ex-vessel
4740 value of landed catch to estimate the ex-vessel value of Columbia River Basin-origin Chinook
4741 salmon and coho salmon in ocean fisheries. In southeast Alaska, data from the ADFG show the
4742 annual average value of Chinook salmon catch between 2013 and 2017 in southeast Alaska as
4743 \$19.5 million (ADFG 2018a). Therefore, the average annual value of Columbia River Basin-origin
4744 Chinook salmon in southeast Alaska is estimated to be \$5.5 million (28 percent of \$19.5
4745 million). Data from NMFS (2014) suggest that the contribution of Columbia River Basin-origin
4746 coho salmon to southeast Alaska fisheries is not substantial.

4747 The allocation scheme described previously for estimating the proportion of Chinook salmon
4748 and coho salmon of Columbia River Basin-origin caught in Oregon and Washington was applied

²² Catch of other salmon species such as sockeye salmon is substantial in Alaska. However, this presentation is limited to Chinook and coho salmon as the only species for which contributions from Columbia Basin stocks are likely substantial, as described later.

²³ The Mitchell Act was enacted in 1938 to conserve the anadromous fishery resources of the Columbia River Basin. The 2014 Mitchell Act EIS is the NEPA analysis of Mitchell Act hatchery programs in the Columbia River Basin.

4749 to estimate ocean catch of Columbia River Basin-origin Chinook salmon and coho salmon in
4750 those states. Altogether, the estimated average annual ocean landings of Columbia River Basin-
4751 origin Chinook salmon from ocean fisheries in Washington, Oregon, and southeast Alaska are
4752 1.7 million pounds while landings for coho salmon are much less (about 3,000 pounds). The
4753 average annual value of Chinook salmon of Columbia River Basin-origin caught in Washington,
4754 Oregon, and southeast Alaska ocean fisheries between 2013 and 2017 is estimated to be \$9.5
4755 million, while the estimated coho salmon value is only about \$3,000.

4756 **Economic Contributions of Columbia River Basin-Origin Fish to Pacific Northwest Region**

4757 A number of efforts have attempted to quantify the total economic contribution of commercial
4758 fisheries to the Pacific Northwest region.²⁴ Below, we summarize a number of relevant findings
4759 of previous research specific to the value of salmon fishing in the Columbia River Basin:

- 4760 • The 2017 Review of Ocean Salmon Fisheries developed by the PFMC found that income
4761 associated with the Columbia River Basin commercial salmon catch (combined non-tribal
4762 and tribal) was \$14.3 million, which was 26 percent below the 2016 estimate of \$19.4
4763 million, corresponding with the trends in ex-vessel values observed in this fishery during
4764 that time (see Table 3-285) (PFMC 2018).
- 4765 • The 2017 EIS for the *United States v. Oregon* harvest management agreement found that
4766 the harvest and primary processing of salmon caught in commercial fisheries in the
4767 Columbia River Basin (based on catch of five harvest indicator stocks) is estimated to
4768 generate \$17.2 million in personal income and supports 419 full-time equivalent jobs in the
4769 region (NMFS 2017).

4770 Additional efforts have described the value of all commercial salmon fishing in the region.
4771 Although these figures include value derived from salmon originating in areas both within and
4772 outside of the Columbia River Basin, they provide a sense of the importance of commercial
4773 salmon fishing generally to the region.

- 4774 • A 2017 report for the PSC found that all commercial salmon fishing in southeast Alaska,
4775 British Columbia, Washington, and Oregon contributed an average of \$256 million in GDP,
4776 \$149 million in labor income, and 3,090 jobs to Washington's economy between 2012 and
4777 2015. These impacts amount to approximately 0.1 percent of the state's total GDP, labor
4778 income, and employment each as compared to statewide totals in 2015. Commercial
4779 salmon fishing in those same locations was estimated to contribute \$58 million in gross
4780 domestic product (GDP) (0.03 percent of statewide total), \$35 million in labor income, and
4781 910 jobs (0.1 percent of statewide total) to Oregon's economy (compared to 2016
4782 statewide totals); and \$417 million in GDP (0.8 percent of statewide total), \$257 million in
4783 labor income (1.3 percent of statewide total), and 5,380 jobs (1.6 percent of statewide
4784 total) to Alaska's economy (compared to 2015 statewide totals) (Gislason et al. 2017;
4785 Federal Reserve Bank of St. Louis 2019a, b, c; Washington State Employment Security

²⁴ As noted previously, the economic value of recreational fisheries is addressed in the Recreation/Environmental Consequences section.

4786 Department 2017; Alaska Department of Labor and Workforce Development 2015; United
4787 States Department of Labor 2019).

4788 • A 2008 report by WDFW found that all commercial salmon fisheries of Washington
4789 contributed \$22.6 million in personal income (\$13.2 million for harvesters and \$9.5 million
4790 for processors), 507 jobs, and had a net economic value of \$7.5 million in 2006 (TCW
4791 Economics 2008). Wages and personal income provided by commercial salmon fishing
4792 accounted for approximately 0.02 percent of the statewide totals in each category
4793 compared to 2009 data (Washington State Employee Security Department 2010). No
4794 allocations between Columbia River Basin-origin fish and non-Columbia River Basin-origin
4795 fish were provided.

4796 In addition to the regional economic contributions of anadromous fish species, particularly
4797 salmon, resident fish species also contribute notably to the economic health of certain
4798 communities. When viewed on a smaller scale, tribal commercial fisheries for resident fish are
4799 important economic drivers, especially for rural communities outside of the anadromous zone.
4800 Recreational fisheries for these species also contribute to the economy of these communities,
4801 as described in Section Recreation/Affected Environment.

4802 **Social Importance of Commercial, Ceremonial and Subsistence Fisheries in The Columbia** 4803 **River Basin²⁵**

4804 ***Tribal Fishing Activities***

4805 Since time immemorial, salmon have been the central focus for the economies, cultures,
4806 lifestyles, and identities of the tribes of the Columbia River Basin. Over time, access of tribes to
4807 this critical resource has been diminished through competition with non-native harvesters and
4808 denial of access to traditional fishing, and more recently through, among other things,
4809 transformation of the rivers through dam construction (Meyer 1999). Despite the diminishment
4810 of the resource, salmon continue to be a key resource of critical importance to the tribes of the
4811 region for personal and family consumption, informal inter-personal distribution and sharing,
4812 community distribution, as well as ceremonial uses. Salmon play a central role in a variety of
4813 ceremonies important to regional tribes including winter ceremonials, the first salmon
4814 ceremony, naming ceremonies, giveaways and feasts, and funerals. In addition to these uses,
4815 salmon also facilitates the intergenerational transfer of knowledge and culture. Young people
4816 are taught by elders the use of fishing gears, preparation and preservation of salmon (e.g.,
4817 smoking), and an appreciation for and awareness of their environment and the place of salmon
4818 within it.

4819 To tribal communities, their obligation to salmon revolves around the concepts of renewal,
4820 reciprocity, and balance (Meyer 1999). CTUIR states in Appendix P that “salmon are the
4821 centerpiece of our culture, religion, spirit, and indeed, our very existence. As Indians, we speak
4822 solely for the salmon. We have no hidden agenda. We do not make decisions to appease special

²⁵ The importance of fisheries to tribal communities is described in the Cultural Resources and Tribal Perspectives sections of the EIS.

4823 interest groups. We do not bow to the will of powerful economic interests. Our people's desire
4824 is simple--to preserve the fish, to preserve our way of life, now and for future generations"
4825 (Donald Sampson, CTUIR). Beyond the cultural value provided by traditional uses of salmon,
4826 and the economic value associated with providing a low-cost source of protein, salmon
4827 provides an important health benefit to tribal members. Interviews presented by Meyer (1999)
4828 describe individual tribal perspectives on the importance of salmon to tribal communities. For
4829 example, a Nez Perce elder described traditional activities, including fishing, hunting, and
4830 gathering as "build[ing] self-esteem for Nez Perce peoples - and this has the capacity to reduce
4831 the level of death by accident, violence and suicide affecting our people. When you engage in
4832 cultural activities you build pride. You are helped to understand "what it is to be a Nez Perce" –
4833 as opposed to trying to be someone who is not a Nez Perce. In this way, the salmon, the game,
4834 the roots, the berries and the plants are the pillars of our world" (Leroy Seth, Nez Perce Elder).

4835 "The loss of the food and the salmon is monumental - and it's all tied together. Food is a really
4836 big part of the Yakama culture - as it is elsewhere. Anywhere you look in the world, food carries
4837 culture. So if you lose your foods, you lose part of your culture - and it has a devastating effect
4838 on the psyche. You also lose the social interaction. When you fish, you spend time together -
4839 you share all the things that impact your life - and you plan together for the next year. Salmon
4840 is more important than just food. In sum, there's a huge connection between salmon and tribal
4841 health. Restoring salmon restores a way of life. It restores physical activity. It restores mental
4842 health. It improves nutrition and thus restores physical health. It restores a traditional food
4843 source, which we know isn't everything - but it's a big deal. It allows families to share time
4844 together and builds connections between family members. It passes on traditions that are
4845 being lost. If the salmon come back, these positive changes would start" (Chris Walsh, Yakama
4846 Psycho-Social Nursing Specialist).

4847 ***Non-Tribal Commercial Fishing***

4848 The Columbia River gillnet communities are concentrated in small towns, villages, and rural
4849 areas adjacent to the Columbia River and areas of the Pacific coast where fishing permits can
4850 also be used. These communities can be identified using the number of fishing permits owned
4851 in an area, the number of fishing vessels owned in an area, and the total value of fish landed in
4852 an area (Martin 2008). Currently, more than two-thirds of licensed Columbia River Basin
4853 gillnetters live in four lower-river counties: Wahkiakum, Pacific and Grays Harbor in
4854 Washington, and Clatsop County in Oregon. The remaining one-third lives along the river, or in
4855 scattered locales throughout the two states and Alaska (Salmon for All 2018).

4856 A previous study examined the social impacts of fishing restrictions and declining natural
4857 resources on these communities (Martin 2005). This study found that downturns in fishing
4858 seasons, coupled with declines in other natural resource-based industries, were negatively
4859 correlated with measures of community health. Social indicators such as poverty, mortality
4860 rates, and social service costs were greater in these communities in the years following fisheries
4861 decline relative to other parts of the state, while economic indicators such as per household
4862 income were within the lowest income category named in the U.S. Census.

4863 On-going work by NMFS Northwest Fisheries Science Center (NWFSC) has developed
4864 community profiles and vulnerability assessments for coastal and some Columbia River Basin
4865 communities based upon methodology developed in the Northeast and Southeast regional
4866 offices of NMFS (Jepson and Colburn 2013). NWFSC collected data to assess coastal and select
4867 communities in the Columbia River Basin as far upstream as Klickitat County, Washington using
4868 social and demographic data from the U.S. Census Bureau and commercial fisheries data from
4869 the Pacific States Marine Fisheries Commission (PSMFC)'s Pacific Fishery Information Network
4870 (PacFIN) (Varney 2018). Each community receives a score for three separate indices (i.e., social
4871 vulnerability, commercial reliance, and commercial engagement) and is ranked into high,
4872 moderate, and low vulnerability categories based on its score relative to all communities
4873 evaluated within the study.

4874 Figure 3-224 presents the results of the NMFS's analysis for communities in the Columbia River
4875 Basin that were included and for which commercial fishing data were available to develop
4876 rankings.²⁶ The communities of Ilwaco, Washington (about 950 residents) and Astoria, OR
4877 (about 10,000 residents) have been identified as being particularly vulnerable to changes in the
4878 fishing industry due to their high engagement in and reliance upon the commercial fishing
4879 industry, as well as social factors that indicate they may be less able to adapt to those changes.
4880 Chinook, Washington (about 450 residents) is also identified as vulnerable. In addition to
4881 gillnetting (considered self-employment), each of these three communities is reliant on fish and
4882 crab processing facilities for a substantial number of jobs (NMFS undated). In these three
4883 communities, between 15 and 18 percent of households live below the national poverty line,
4884 according to 2000 U.S. Census Data, relative to about 15 percent nationwide. It is important to
4885 note, however, that the analysis considers engagement in and reliance upon all fishing
4886 activities, and the degree to which these communities are specifically engaged in or reliant
4887 upon Columbia River Basin fisheries is not discernable from these results. Community profiles
4888 of west coast fishing communities developed by NMFS indicate that a large number of residents
4889 in Astoria, for example, participate in the lower Columbia River gillnet fishery, targeting salmon,
4890 shad, sturgeon, and eulachon. However, residents of these communities are also involved in
4891 other fisheries including Dungeness crab, coastal pelagic species, groundfish, and shrimp (NMFS
4892 undated).

²⁶ Note the upstream extent of the analysis is Klickitat County, WA. Additionally, because NMFS reports many Columbia River ports in Oregon as a single group, it is not currently possible to assign commercial engagement or commercial reliance scores to these communities individually. As a result, many Oregon-side Columbia ports are not reported here.



4893
4894 **Figure 3-224. Results of NMFS Community Vulnerability Assessment for Columbia River Basin**
4895 **Communities Downstream of Klickitat County, Washington**

4896 Note: The Commercial Engagement index is used to measure how a community interacts with the fishing industry
4897 in order to determine how the community will respond to the proposed MOs. The Commercial Reliance index is
4898 used to measure how reliant a community is on the fishing industry, to assess how it will be affected by the
4899 changes of the proposed MOs. The Social Vulnerability index considers how resilient a community's population
4900 may be to changes in the fisheries on which they depend.

4901 Commercial Engagement and Reliance scores reflect all commercial fishing activity, not just that portion which is
4902 dependent upon Columbia River Basin-origin fish.

4903 Source: Map created by author using data from Varney (2018)

4904 **3.15.2.2 Passive Use**

4905 Passive use values, also referred to as “non-use values,” are the values people hold for the
4906 continued existence of a resource beyond any current or future use.²⁷ These values are thought
4907 to measure the intrinsic values people hold for natural resources or ecological health and

²⁷ Various definitions of passive use values exist in the literature, some of which also distinguish between passive use values and non-use values. This section relies on a commonplace definition used in many of the studies referenced in this section as well as the definition recognized by the Northwest Power and Conservation Council and in guidance provided by the National Oceanic and Atmospheric Administration (NOAA 1994).

4908 functioning.²⁸ While different definitions are used across studies, economists generally see
4909 these values are motivated by three key factors:

- 4910 • Existence value, defined as the benefit gained simply from knowing the resource exists;
- 4911 • Option value, allowing for potential use of the resource in the future; and/or
- 4912 • Bequest value, reflecting a desire to ensure the continued existence of the resource for
4913 future generations.

4914 The total economic value (TEV) of a resource is the combined total of all use values and passive
4915 use values, which together represent the full value a resource brings to society. Although
4916 passive use values research generally focuses on fish and wildlife species, theoretically people
4917 may hold passive use values for many types of resources. In the context of the Columbia and
4918 Snake rivers, salmon are a resource for which passive use values are often considered an
4919 important part of TEV. Existing research on passive use values for dam breaching and free-
4920 flowing rivers also typically focuses on the expected benefits to salmon or other fish and
4921 wildlife species (e.g., Douglas and Taylor 1999, Loomis 1996a, 1996b, Mansfield et al. 2012,
4922 Hanemann et al. 1991). Use values for salmon contain both market (e.g., commercial fisheries)
4923 and non-market (e.g., recreation) components,²⁹ while passive use values are strictly not
4924 observable in a market or in people’s behavior. TEV values, therefore, should not be summed
4925 with other values because it may result in double-counting. This section summarizes the
4926 findings of existing studies that have evaluated passive use values for Pacific salmon and other
4927 Columbia River Basin resources, and describes how this research relates to the CRSO EIS. Given
4928 the limitations of the existing literature and uncertainty of the changes in overall fish
4929 abundance predicted under each MO, this EIS does not include a quantitative benefit transfer
4930 of passive use values. It does, however, acknowledge that the literature demonstrates that the
4931 general public holds passive use values, and that the population that may experience social
4932 welfare benefits from increased salmon populations may be geographically far-reaching.

4933 **METHODS FOR QUANTIFYING PASSIVE USE VALUES**

4934 Quantifying passive use values requires survey-based “stated preference” methods. The most
4935 common stated preference methodology employed in passive use value research is contingent
4936 valuation, which is a means of eliciting an individual’s or a household’s maximum willingness-

²⁸ Passive use values are not to be confused with cultural and spiritual values. Past efforts to quantify passive use values focused on the general population and did not consider tribes and, therefore, are not reflective of the value structure of tribes. Often tribes do not agree with assigning a monetary value to cultural and spiritual values. Thus, economists do not typically attempt to monetize these values. Information on tribal perspectives can be found in Section 3.18 and Appendix P of this EIS.

²⁹ While people may spend money to participate in recreation (therefore contributing to regional economic productivity), in this context the “economic value” of recreation refers to the utility that people gain from participating in recreational fishing. The contribution of recreational fishing to people’s sense of well-being is considered a non-market value.

4937 to-pay (WTP) for a given resource or ecological improvement.³⁰ These surveys present
4938 respondents with hypothetical scenarios for changes in a given resource, and a “price tag”
4939 associated with each scenario, then asks the respondents to either choose between scenarios
4940 or assign a yes/no value to a given scenario and cost option. Responses are then used to
4941 calculate an average WTP for each scenario among respondents.

4942 Benefit transfer, a methodology that applies results from existing relevant studies to a new
4943 resource or context, is commonly used when primary survey research is not feasible or
4944 practical. Several types of benefit transfer methods exist, and all apply the results of one or
4945 more studies to another context by making adjustments based on the differences between the
4946 existing studies and new context. Benefit transfer analysis relies on objective analysis of
4947 whether the results of one analysis can be applied elsewhere, and on the analyst to “make a
4948 case” regarding the applicability of results from one study to another. Several sources identify
4949 best practices when using benefit transfer (EPA 2014; Johnston et al. 2015; OMB 2003), and
4950 others acknowledge the challenges and shortcomings of the methodology (Newbold et al.
4951 2018).

4952 **RESEARCH ON PASSIVE USE VALUES FOR SALMON**

4953 This review prioritizes studies focused on regional fish species found in the Columbia and Snake
4954 rivers and includes results from both primary survey research and benefit transfer methods.
4955 Existing research also suggests that people may hold passive use values for other resources and
4956 species found in the Columbia and Snake River Basins, including marine species that prey on
4957 salmon as well as other threatened and endangered species. Additionally, the economics
4958 literature includes research on passive use values for free-flowing rivers. These studies
4959 generally bundle the environmental changes associated with free-flowing rivers, including, for
4960 example, specifying effects on fish populations. This section focuses on passive use research on
4961 salmon.

4962 While passive use values are distinct from use values, it is difficult to design a survey that can
4963 isolate passive use from use components of TEV. This is because, as previously described,
4964 survey respondents may value a resource, such as salmon, for multiple reasons, including
4965 recreation, commercial fishing, ecological importance, or passive use. It may be difficult for
4966 survey respondents to divide the value they hold for the resource into the specific components
4967 (e.g., Richardson and Loomis 2009). For this reason, many studies focus on quantifying TEV
4968 rather than exclusively passive use values. Some studies, however, conduct analysis on a
4969 population sample that is not expected to hold use values for the resource (e.g., people who
4970 live in the nearby watershed but indicate they do not participate in fisheries or recreation, or
4971 people who live far from the watershed and have a low probability of ever using the resource)

³⁰ From an economics perspective, the value that an individual (or population) holds for a resource may be measured in terms of WTP, which is the maximum amount that the individual (or population) would be willing to pay rather than do without the resource.

4972 to estimate a value that may be interpreted as passive use. This literature summary includes
4973 both passive use and TEV studies.

4974 A total of 18 studies were identified that estimate passive use or TEV for salmon of relevance to
4975 the Columbia River Basin ecosystem, including 13 primary studies and 5 studies employing
4976 benefit transfer methods. Primary survey studies regarding Pacific salmon are listed in
4977 Table 3-285 and are summarized in below. Related benefit transfer studies are also summarized
4978 in the text below.

4979 Every primary study included in this review identifies positive average WTP values for Pacific
4980 salmon, meaning the existing body of research consistently finds that the surveyed populations
4981 hold some value for salmon beyond any direct or indirect use. Generally, these studies focus on
4982 eliciting information on the value people hold for specified increases in populations of
4983 particular types of salmon. There are a few studies, however, that focus on a broad range of
4984 effects related to dam removal and the associated impacts on river flow, which include but are
4985 not limited to changes in salmon populations. Moreover, the studies represent a range of
4986 baseline salmon population abundance and hypothetical population change scenarios,
4987 including both increases in percent over a baseline level or “downlisting” from endangered to
4988 threatened or recovery. The studies also reflect surveys administered among different
4989 respondent populations, which vary geographically, some of which are now quite dated (up to
4990 25 years old). For these reasons, the results of the studies cannot be directly compared to one
4991 another.

4992 **Primary Research Specific to Removal of the Lower Snake River Dams**

4993 One existing primary survey study is specific to the values individuals assign to the salmon
4994 affected by the lower Snake River dams. ECONorthwest conducted an analysis based on a
4995 survey among active voters in Washington State conducted by Save Our Wild Salmon
4996 (ECONorthwest 2019). Specifically, the relevant survey question asked respondents if they were
4997 willing to pay an additional \$x (where values were randomly assigned across respondents) on
4998 their electric bill to restore wild salmon and improve water quality by removing four dams on
4999 the lower Snake River. ECONorthwest analyzed the survey responses to estimate an average
5000 WTP of \$26 to \$48 per household per year, depending on the discount rate applied. They
5001 multiplied these values by the number of households in the five-state region referenced in the
5002 2002 EIS to estimate a population-level, 20-year present value of passive use benefits ranging
5003 from \$5.1 billion to \$7.0 billion assuming a seven percent discount rate (equivalent to \$12 to
5004 \$16 billion assuming a 2.75 percent discount rate).³¹ Based on the survey question, the results
5005 of this analysis are likely to reflect TEV rather than the passive use component exclusively, and
5006 may potentially reflect the respondents’ perceptions of other outcomes related to dam
5007 removal. While the single question survey focuses specifically on the removal of the lower
5008 Snake River dams, it presumes that this scenario would “restore” wild salmon. Additionally, the

³¹ The study does not report annualized values. However, for comparison with other studies, the annualized benefits range from \$440 million to \$600 million (7 percent discount rate) to \$720 million to \$990 million (2.75 percent discount rate) based on the total present values and discount rates provided.

5009 study applies WTP values reported by Washington households to all households across four
5010 additional states.

5011 **Benefit Transfer Studies**

5012 Existing benefit transfer studies relevant to the salmon in the Columbia and Snake Rivers that
5013 make use of these primary studies do not converge around a single WTP value, and their
5014 resulting estimates are highly influenced by the benefit transfer method selected. For example,
5015 Weber (2015) compares four benefit transfer methods and finds very different WTP values per
5016 household depending on the method applied. Moreover, the results of these benefit transfer
5017 studies generally reflect TEV and not the passive use component exclusively. Finally, in some
5018 cases per household values are estimated while in others only population aggregates are
5019 reported.

5020 For example, Richardson and Loomis (2009) conducted an update of a meta-analysis originally
5021 published by Loomis and White (1996) that explores WTP across multiple endangered and
5022 threatened species types and offers their resulting mathematical model for benefit transfer to
5023 other contexts. Their models integrate findings of several primary studies included in this
5024 review, and both studies make clear that their resulting estimates are TEV, not passive use.
5025 Based on existing literature, Loomis and White (1996) find an average WTP of \$102 per
5026 household for the increase in population of various Pacific salmon and steelhead while
5027 Richardson and Loomis (2009) find an average WTP of \$298 per household for increase in
5028 population of various Washington state anadromous fish. The larger value reported by
5029 Richardson and Loomis (2009) reflects an increase in reported WTP values across surveys over
5030 time.

5031 A report by Earth Economics applied the mathematical model provided by Richardson and
5032 Loomis (2009) to estimate the “existence values” for salmon under present and hypothetical
5033 future conditions in the Columbia River (Flores et al. 2017). This study estimates an aggregate
5034 existence value across all 2.8 million households in the Columbia River Basin of \$38.4 million
5035 annually for the current scenario versus \$1.1 billion annually for a scenario where salmon
5036 populations increase by 51 percent. There is some uncertainty about the method used to
5037 estimate the 51 percent increase salmon population levels for the future scenario. Moreover,
5038 the study describes these estimates as “existence values” (i.e., synonymous with passive use
5039 values) that are additive with other types of values quantified and described in their report,
5040 including commercial fishing, recreational fishing, and cultural values. Based on the method
5041 employed to quantify these values, however, they are more likely reflective of a TEV estimate
5042 and should not be summed with other types of values.

5043 Another study considers recovery of spring Chinook salmon in the Willamette Valley of Oregon
5044 as a case study for investigating various benefit transfer techniques for TEV estimation (Weber
5045 2015). Six of the studies identified in this review are used in the Weber (2015) study. The study
5046 finds that households in the immediate watershed are WTP \$49 to \$4,645 per household to
5047 double the spring Chinook salmon population, depending on the transfer model employed. This
5048 broad range is indicative of the variability of the source studies used to support the benefit

5049 transfer and leads the study to conclude that studies attempting to leverage the existing
5050 literature to value changes in salmon should employ multiple transfer approaches as sensitivity
5051 analysis or else identify a single study that closely matches the policy context for the benefit
5052 transfer. The study also notes that the research available for benefit transfer is limited in its
5053 distinction of wild and hatchery salmon, which makes interpretation for policy purposes
5054 difficult as wild and hatchery salmon may be affected differently and it is unclear if the
5055 surveyed populations value them differently.

5056 The Lower Snake River Juvenile Salmon Mitigation Feasibility Report and Environmental Impact
5057 Statement included a benefit transfer for salmon specific to the breaching of dams on the lower
5058 Snake River (Corps 2002). For the dam removal scenario, the 2002 EIS estimates passive use
5059 values associated with an increase in wild salmon returns ranging from \$31 to \$414 million per
5060 year among households in the Pacific Northwest and California. The Independent Economic
5061 Analysis Board of the Northwest Power Planning Council review of the study (2000) identified
5062 methodological concerns with this study, including that it did not account for potential
5063 diminishing returns in assuming a single per fish value and multiplying it by the estimated returns.

5064 **Relevance to the CRSO EIS**

5065 The existing literature on passive use and TEV for salmon is generally based on changes in
5066 overall salmon abundance. The life cycle for anadromous fish is complicated and various
5067 aspects of fish survival may be affected by each CRSO EIS action alternative (e.g., juvenile in-
5068 river survival, adult returns). Thus, the CRSO EIS assesses effects of the MOs on fish in terms of
5069 multiple different metrics; changes in abundance are only quantified for some salmon stocks.

5070 This analysis considers the applicability of the existing literature to the CRSO EIS given best
5071 practices for benefit transfer. While the existing literature identifies a positive WTP for
5072 improving salmon populations, it is also clear that the specific value of a given population-level
5073 effect is uncertain. Studies conducted 20 to 30 years ago rely on outdated survey
5074 methodologies and baseline conditions for salmon populations, calling into question whether
5075 they accurately reflect current values held by the public. The more recent surveys have
5076 generally involved small sample sizes, and narrowly define the resource change (e.g.,
5077 “restoring” salmon or removing a specific dam). Finally, the study that most closely matches the
5078 policy context of an MO, the ECONorthwest lower Snake River dam removal study, presupposes
5079 that the dam breach will “restore” wild salmon.

5080 Best practices for benefit transfer identified in OMB Circular A-4 describe that meeting all
5081 criteria is difficult and that “professional judgment is required in determining whether a
5082 particular transfer is too speculative...” (OMB 2003, 26). Given the limitations of the existing
5083 literature, this EIS does not include a quantitative benefit transfer of passive use values. This
5084 analysis acknowledges that the general public holds passive use values, and that the population
5085 that may experience social welfare benefits from increased salmon populations may be
5086 geographically far-reaching.

5087 **Table 3-285. Summary of Findings from Primary Studies**

Study	Site of resource	Resource valued	WTP per household (2019 Q1 dollars) ²
Passive use			
Olsen et al. (1991)	Columbia River Basin, OR	Doubling salmon and steelhead runs from 2.5 to 5 million	\$48 per year perpetually (for non-users)
Wallmo and Lew (2012)	Pacific Northwest	Downlisting Upper Willamette River Chinook salmon and Puget Sound Chinook salmon in 50 years	\$46 per year for Upper Willamette River Chinook salmon and Puget Sound Chinook salmon (mostly non-users)
Wallmo and Lew (2015, 2016)	Central and Southern CA	Downlisting central CA coho salmon and southern CA steelhead in 50 years	\$59 per year for 10 years for coho salmon (mostly non-users) \$82 per year for 10 years for steelhead (mostly non-users)
Johnston et al. (2015)	Puget Sound, WA and Upper Willamette, OR	Downlisting Chinook salmon in 50 years	\$27 per year for 10 years for Puget Sound Chinook salmon (mostly non-users) \$32 per year for 10 years for Upper Willamette Chinook salmon (mostly non-users)
Douglas and Taylor (1999)	Trinity River, CA	River augmentation effects, including on fish population (five scenarios: 9,000 – 105,000 increase)	\$12-\$92 per year indefinitely (for non-users)
Loomis (1996a, 1996b)	Elwha River, WA	Dam removal, resulting in 300,000 more salmon and steelhead from a baseline of 50,000 fish (four species)	\$108 per year for 10 years (for residents of the U.S. outside of WA, perceived non-users)
Mansfield et al. (2012)	Klamath River Basin, OR and CA	Dam removal effects, including on fish population (coho salmon, steelhead, suckers)	\$238 per year for 20 years (for residents of the U.S. outside of OR and CA, perceived non-users)
Total economic value (TEV), including passive use			
Bell et al. (2003)	Five estuaries in WA and OR	Double or quadruple coho salmon in WA and delist coho salmon in OR	\$108-\$174 per year for 5 years for two WA estuaries \$30-\$172 per year for 5 years for three OR estuaries
Layton et al. (1999)	Columbia River, Oregon	Changes in fish population (various scenarios, species)	\$176-\$337 per year for 20 years
Garber-Yonts et al. (2004)	Coastal Range of OR	Restoring salmon habitat 10% above baseline levels, with goal of increasing salmon population	\$88 per year
Stratus Consulting (2015)	Elwha River, WA	Restoration of salmon at limited (25-50% increase) or extensive (60% increase) levels	\$298 per year for limited increase \$354 per year for extensive increase
ECONorthwest (2019)	Lower Snake River, WA	Restore wild salmon and improve water quality by removing four dams	\$26-48 per household per year

Study	Site of resource	Resource valued	WTP per household (2019 Q1 dollars)²
Hanemann et al. (1991)	San Joaquin River, CA	Restore flow of river, resulting in increase in Chinook salmon population	\$328-\$610 per year (for CA resident sub-sample)
Loomis (1996a, 1996b)	Elwha River, WA	Dam removal, resulting in 300,000 more salmon and steelhead from a baseline of 50,000 fish (four species)	\$93 per year for 10 years (for residents of the county surrounding the watershed)
Mansfield et al. (2012)	Klamath River Basin, OR and CA	Dam removal effects, including on fish population (coho salmon, steelhead, suckers)	\$138 per year for 20 years (for residents of the Klamath River area)

5088 Notes:

5089 Only primary studies are included in this table. Benefit transfer studies are described in the main text.

5090 All WTP values adjusted from their survey year to Q1 2019 USD using a GDP deflator from the Bureau of Economic
5091 Analysis (Table 1.1.9).

5092 **3.15.3 Environmental Consequences**

5093 **3.15.3.1 Methodology**

5094 This analysis evaluates potential impacts on fisheries by referencing the potential effects on
5095 relevant fish populations, as described in Section 3.5. There are no anticipated effects to
5096 fisheries in Canada under any alternative.

5097 **3.15.3.2 No Action Alternative**

5098 **SOCIAL WELFARE EFFECTS**

5099 The social welfare effects analysis considers the extent to which the effects of the alternatives
5100 on fish (as described in Section 3.5) affect the economic value of commercial fisheries.^{32,33}
5101 Ongoing trends with regard to both non-tribal and tribal commercial fisheries would be
5102 expected to continue under the No Action Alternative. Under this alternative, most non-tribal
5103 commercial fishing activity would continue to occur downstream of Bonneville Dam, while
5104 tribal commercial fishing would continue to be concentrated primarily between Bonneville Dam
5105 and McNary Dam (Region D).

5106 Under the No Action Alternative, Chinook salmon and coho salmon would continue to provide
5107 the greatest commercial value of all species originating from the Columbia River Basin. Because
5108 there is no clear trend, this analysis assumes that catch would continue consistent with recent
5109 trends under the No Action Alternative for these species. Fall and spring-run Chinook salmon

³² From an economic perspective, changes in the "value" of a commercial fishery are expressed in terms of changes in producer and consumer surplus in the market. However, this analysis undertakes a qualitative evaluation of the potential social welfare effects.

³³ Impacts to recreational fisheries are discussed in the Recreation/Env. Consequences section. Impacts to ceremonial and subsistence fisheries are discussed in the "Other Social Effects" section of this discussion.

5110 would be anticipated to continue to make up the largest proportion of the commercial catch
5111 value under the No Action Alternative.

5112 Chinook salmon from the Columbia River Basin will also contribute substantially to ocean
5113 fisheries in Oregon, Washington, and Alaska. Trends in ocean catch of Chinook salmon over the
5114 last ten years suggest that landings and value of Chinook salmon has fluctuated between years,
5115 but has ranged between \$13 million and \$25 million in Alaska, of which approximately 28
5116 percent are of Columbia River Basin origin. In Oregon and Washington, value has ranged
5117 between \$2 million and \$18 million in Oregon and Washington, of which approximately 32
5118 percent are of Columbia River Basin origin. This analysis assumes these general ranges of value
5119 for ocean fisheries will persist in the future under the No Action Alternative.

5120 Under the No Action Alternative, steelhead would continue to be an important commercial
5121 target for tribal commercial fishermen in the area between Bonneville Dam and McNary Dam
5122 (Region D). Under the No Action Alternative, white sturgeon and, to a lesser extent, American
5123 shad, and Pacific eulachon would continue to be caught for commercial purposes in the
5124 Columbia River Basin. Commercial fishing activities for these species would be concentrated
5125 below McNary Dam. Commercial catch of sturgeon in Zone 6 has fallen steadily since 2001, but
5126 measured since 1996, catches have been cyclical as abundance has fluctuated (Sturgeon
5127 Management Task Force 2019). This fishery is expected to persist at relatively low numbers of
5128 fish caught, under the No Action Alternative. Commercial interest in shad has fluctuated
5129 dramatically over the last half-decade, and the low price of shad has resulted in a lessened
5130 interest in this fish commercially in recent years. Commercial catch of shad is expected to be
5131 minimal under the No Action Alternative. Under the No Action Alternative, catch of eulachon is
5132 expected to continue at low levels.

5133 **REGIONAL ECONOMIC EFFECTS**

5134 Under the No Action Alternative, commercial fishing would continue to provide important
5135 contributions to the regional economies of the Columbia River Basin. Catch and processing of
5136 fish from the Columbia River Basin, as well as related service industries that support these
5137 fisheries, would continue to provide employment and income to the region. Communities such
5138 as Astoria, Oregon; Illwaco, Washington; and Chinook, Washington would continue to be
5139 particularly dependent upon the commercial fishing industry.

5140 **OTHER SOCIAL EFFECTS**

5141 **Non-Tribal**

5142 Commercial gillnetting, the primary means of non-tribal salmon fishing in the Columbia River
5143 Basin, is a tradition passed down through generations and is an important element of cultural
5144 identity and the social fabric of many coastal Oregon and Washington communities. More than
5145 two-thirds of licensed Columbia River Basin gillnetters live in Wahkiakum, Pacific, and Grays
5146 Harbor counties in Washington, and Clatsop County in Oregon. The remaining one-third lives
5147 along the river, or elsewhere in Oregon, Washington, and Alaska (Salmon for All 2018). Given

5148 their high level of involvement in the fishing industry, and existing social conditions, the
5149 communities of Ilwaco, Washington, Astoria, Oregon, and Chinook, Washington are particularly
5150 vulnerable to changes in fishing activity. Although communities such as Astoria are heavily
5151 involved in gillnetting, fisheries such as Dungeness crab, coastal pelagic species, groundfish, and
5152 shrimp also support the fishing industry in these communities (NMFS undated). The social and
5153 economic importance of salmon fishing to these communities is not anticipated to change
5154 under the No Action Alternative.

5155 **Tribal**

5156 In addition to participating in commercial fishing, tribes in the Columbia River Basin also rely
5157 upon numerous anadromous and resident fish species for ceremonial and subsistence
5158 purposes. Under the No Action Alternative, catch of salmon, steelhead, and other culturally
5159 important species for ceremonial and subsistence purposes would continue to occur both in the
5160 mainstem rivers and in tributaries throughout the Basin. Ceremonial and subsistence fishing
5161 activities would continue to target spring-run Chinook salmon in particular, but would also
5162 include catch of coho salmon, steelhead, summer- and fall-run Chinook salmon, lamprey,
5163 kokanee salmon, bull trout, and burbot, among others. Ongoing effects of inundation and
5164 reservoir fluctuation would continue to have adverse effects on resident fish availability for
5165 ceremonial and subsistence uses under the No Action Alternative.

5166 **SUMMARY OF EFFECTS**

5167 Commercial fishing and ceremonial and subsistence fishing for anadromous fish would continue
5168 to contribute substantially to the economy of the region, as well as to the social fabric and
5169 culture of both non-tribal and tribal communities. Adult and juvenile migration and survival of
5170 anadromous species, and the fisheries that depend on them, would continue to be limited by
5171 conditions in the basin. Ceremonial and subsistence fishing for resident species would continue
5172 to play a critical role in maintaining tribal culture and community, particularly for tribes in the
5173 upper basin, and the survival of the species on which these fisheries depend would continue to
5174 be limited by existing conditions.

5175 **3.15.3.3 Multiple Objective Alternative 1**

5176 **SOCIAL WELFARE EFFECTS**

5177 The social welfare effects analysis considers the extent to which the effects of the alternatives
5178 on fish (as described in Section 3.5) affect the economic value of commercial fisheries.^{34,35}
5179 Under MO1, in Region C, effects to anadromous fish range from potential negligible beneficial
5180 increases to moderate increases depending on latent mortality assumptions. However, some

³⁴ From an economic perspective, changes in the "value" of a commercial fishery are expressed in terms of changes in producer and consumer surplus in the market. However, this analysis undertakes a qualitative evaluation of the potential social welfare effects.

³⁵ Impacts to recreational fisheries are discussed in the Recreation/Environmental Consequences section. Impacts to ceremonial and subsistence fisheries are discussed in the "Other Social Effects" section of this discussion.

5181 species are anticipated to have the potential for minor adverse effects, particularly sockeye
5182 salmon and fall Chinook salmon, based on warmer summer water temperatures. The effects of
5183 MO1 in Region D are anticipated to be similar to those in Region C. MO1 is not anticipated to
5184 have effects on anadromous species that differ markedly from the No Action Alternative in
5185 Region B. To the extent that changes in fish abundance results in corollary changes in
5186 commercial fish harvest, MO1 is anticipated to have mixed social welfare effects ranging from
5187 minor adverse to minor beneficial effects to commercial fisheries targeting these populations.

5188 **REGIONAL ECONOMIC IMPACTS**

5189 Because MO1 is likely to result in minor adverse to minor beneficial changes to commercial
5190 fisheries relative to the No Action Alternative, regional economic effects associated with these
5191 changes are anticipated to be minor to negligible under MO1.

5192 **OTHER SOCIAL EFFECTS**

5193 **Non-Tribal**

5194 Because MO1 is likely to result in generally minor to negligible changes to commercial fisheries
5195 relative to the No Action Alternative, changes to other social effects of commercial fishing are
5196 also anticipated to be minor to negligible under MO1.

5197 **Tribal** MO1 is predicted to have some minor beneficial effects on certain anadromous fish
5198 species and minor adverse effects for others. Overall, effects are predicted to be minor to
5199 negligible. MO1 is thus likely to result in minor to negligible changes to ceremonial and
5200 subsistence fisheries for anadromous species relative to the No Action Alternative.

5201 MO1 may result in minor to moderate effects, both beneficial and adverse, to resident fish,
5202 which could have corresponding effects to ceremonial and subsistence fishing activities. In
5203 Region A, MO1 would have minor to moderate adverse effects on bull trout and Kootenai River
5204 white sturgeon. Burbot may be similarly affected. In Region B, MO1 would have negligible,
5205 minor to localized moderate adverse effects to resident fish in Lake Roosevelt such as kokanee,
5206 redband rainbow trout, white sturgeon, and burbot, stemming from increased entrainment,
5207 varial zone effects (important for migration), and in the river reach, a minor reduction in
5208 sturgeon recruitment in Region B. In Regions C and D, MO1 would have minor adverse effects
5209 to resident fish due to warmer summer water temperatures, reduced flows, or increased TDG
5210 and potential for gas bubble trauma. Ceremonial and subsistence fishing for resident species
5211 could be adversely affected in these areas.

5212 **SUMMARY OF EFFECTS**

5213 MO1 is anticipated to result in minor to negligible effects on commercial and ceremonial and
5214 subsistence fisheries for anadromous fish species as compared to the No Action Alternative. As
5215 a result, social welfare effects, regional economic impacts, and other social effects are likewise

5216 anticipated to be minor to negligible. Potential localized adverse effects on resident fish may
5217 result in some adverse effects on ceremonial and subsistence fisheries across all regions.

5218 **3.15.3.4 Multiple Objective Alternative 2**

5219 **SOCIAL WELFARE EFFECTS**

5220 The social welfare effects analysis considers the extent to which the effects of the alternatives
5221 on fish (as described in Section 3.5) affect the economic value of commercial fisheries.^{36,37} MO2
5222 is anticipated to have a number of adverse effects on anadromous fish populations across the
5223 regions. In Region B, Upper Columbia River salmon and steelhead below Chief Joseph Dam
5224 would be adversely affected. Under MO2, decreased abundance of Snake River spring Chinook
5225 salmon and Snake River steelhead are predicted by the CSS model in Region C. In Region D,
5226 decreased abundance of Snake River spring Chinook and Snake River steelhead, upper
5227 Columbia River spring Chinook salmon, and decreased in-river survival rates of upper Columbia
5228 River steelhead would contribute to adverse effects on commercial fishing opportunities on the
5229 Columbia River. To the extent that these adverse effects result in reduced adult abundance for
5230 these populations, there is the potential for adverse changes in commercial fish catch and
5231 associated social welfare effects for these species.

5232 **REGIONAL ECONOMIC IMPACTS**

5233 Because MO2 is likely to result in adverse effects on the adult abundance of certain
5234 commercially important fish populations compared to the No Action Alternative, MO2 may
5235 result in some adverse regional economic effects if reductions in commercial fishing catch
5236 occurs.

5237 **OTHER SOCIAL EFFECTS**

5238 **Non-Tribal**

5239 Because MO2 is likely to adversely affect some commercially important fish populations, MO2
5240 may result in some adverse social effects if the level of commercially caught fish decreases
5241 under this alternative compared to the No Action Alternative.

5242 **Tribal**

5243 MO2 may result in adverse effects on anadromous fish of great ceremonial and subsistence
5244 value to tribes. As described above, adverse effects to these species are anticipated in Regions
5245 B, C, and D. To the extent these effects result in decreased opportunity to catch these species in

³⁶ From an economic perspective, changes in the "value" of a commercial fishery are expressed in terms of changes in producer and consumer surplus in the market. However, this analysis undertakes a qualitative evaluation of the potential social welfare effects.

³⁷ Impacts to recreational fisheries are discussed in the Recreation/Environmental Consequences section. Impacts to ceremonial and subsistence fisheries are discussed in the "Other Social Effects" section of this discussion.

5246 ceremonial and subsistence fisheries, MO2 may result in adverse social and cultural effects on
5247 tribes.

5248 MO2 is anticipated to result in adverse effects on resident fish in localized areas. In Region A,
5249 higher winter flows downstream of Libby Dam on the Kootenai River in late fall and
5250 downstream of Hungry Horse dam in the winter may result in adverse effects to resident fish.
5251 MO2 may also result in decreased habitat for white sturgeon on the Kootenai River. In Region
5252 B, MO2 may result in increased entrainment for resident species in Lake Roosevelt such as bull
5253 trout, kokanee, rainbow trout, and burbot. In Region C, adverse effects to kokanee at Dworshak
5254 Reservoir are anticipated. Ceremonial and subsistence fisheries relying upon these resident fish
5255 would also be adversely affected if these effects result in decreased opportunities to harvest
5256 these fish. Adverse effects to ceremonial and subsistence fisheries of resident fish would occur
5257 in Regions A, B, and C under MO2.

5258 **SUMMARY OF EFFECTS**

5259 The fish analysis predicts that MO2 will generally result in moderate adverse effects to both
5260 anadromous and resident fish species across all regions, although there may be some minor to
5261 major adverse effects in localized areas. To the extent that the predicted effects result in
5262 decreased abundance of these species, and a decreased opportunity for commercial and
5263 ceremonial and subsistence harvest of these species, minor to moderate adverse social and
5264 cultural effects may be anticipated under MO2.

5265 **3.15.3.5 Multiple Objective Alternative 3**

5266 **SOCIAL WELFARE EFFECTS**

5267 The social welfare effects analysis considers the extent to which the effects of the alternatives
5268 on fish (as described in Section 3.5) affect the economic value of commercial fisheries.^{38,39}
5269 Under MO3, the breaching of the dams will result in short-term adverse effects for most
5270 species in Region C, but long-term beneficial effects on key anadromous species of commercial
5271 importance, particularly Snake River Chinook salmon and steelhead. In Region D, long-term
5272 increases in abundance of salmon and steelhead, as well as white sturgeon, are also
5273 anticipated. To the extent that these results indicate that adult fish abundance will increase in
5274 the future, benefits to commercial catch for these species may occur.

5275 **REGIONAL ECONOMIC IMPACTS**

5276 Because MO3 is likely to result in benefits to certain commercially important anadromous fish
5277 populations compared to the No Action Alternative in the long term, MO3 may result in some

³⁸ From an economic perspective, changes in the "value" of a commercial fishery are expressed in terms of changes in producer and consumer surplus in the market. However, this analysis undertakes a qualitative evaluation of the potential social welfare effects.

³⁹ Impacts to recreational fisheries are discussed in the Recreation/Environmental Consequences section. Impacts to ceremonial and subsistence fisheries are discussed in the "Other Social Effects" section of this discussion.

5278 increases in regional economic effects of commercial fishing activities if increases in commercial
5279 fishing catch occur.

5280 **OTHER SOCIAL EFFECTS**

5281 **Non-Tribal**

5282 Because MO3 is likely to benefit some commercially important anadromous fish populations
5283 compared to the No Action Alternative in the long term, MO3 may result in some beneficial
5284 social effects, if the level of fish caught for commercial, increases under this alternative.

5285 **Tribal**

5286 Because of the anticipated long-term benefits of MO3 on anadromous fish species, MO3 may
5287 result in beneficial tribal cultural and social effects, if the level of fish caught for ceremonial or
5288 subsistence purposed increases under this alternative. However, MO3 may result in some
5289 mixed tribal social and cultural effects due to effects of the alternative on resident fish in
5290 certain regions. In particular, in Region A, MO3 may have minor to moderate adverse effects on
5291 bull trout and Kootenai River white sturgeon due to food web effects, varial zones, and habitat
5292 loss. In contrast, in Region C, MO3 is anticipated to result in long-term benefits for some species
5293 of ceremonial and subsistence importance, such as white sturgeon and bull trout.

5294 **SUMMARY OF EFFECTS**

5295 Commercial and ceremonial and subsistence fisheries targeting anadromous fish species across
5296 all regions may see major beneficial effects in the long term. Ceremonial and subsistence
5297 fisheries targeting residential species in Region C may see long term benefits, while those in
5298 Regions A may experience some moderate adverse effects.

5299 ***3.15.3.6 Multiple Objective Alternative 4***

5300 **SOCIAL WELFARE EFFECTS**

5301 The social welfare effects analysis considers the extent to which the effects of the alternatives
5302 on fish (as described in Section 3.5) affect the economic value of commercial fisheries.^{40,41} MO4
5303 is anticipated to result in minor beneficial effects to anadromous fish species in Regions B, C,
5304 and D. In Region B, there may be slight long-term beneficial effects in numerous response
5305 metrics for Chinook salmon and steelhead. Under MO4, instream survival of modeled
5306 anadromous fish species would increase slightly compared to the No Action Alternative in
5307 Region C. In Region D, anadromous fish species are anticipated to experience potentially minor

⁴⁰ From an economic perspective, changes in the "value" of a commercial fishery are expressed in terms of changes in producer and consumer surplus in the market. However, this analysis undertakes a qualitative evaluation of the potential social welfare effects.

⁴¹ Impacts to recreational fisheries are discussed in the Recreation/Environmental Consequences section. Impacts to ceremonial and subsistence fisheries are discussed in the "Other Social Effects" section of this discussion.

5308 benefits under MO4. To the extent that these findings indicate that adult fish abundance will
5309 increase, and that commercial harvest increases as a result, benefits to commercial fisheries for
5310 these species may occur.

5311 **REGIONAL ECONOMIC IMPACTS**

5312 Because MO4 is likely to result in minor benefits to certain commercially important
5313 anadromous fish populations compared to the No Action Alternative, MO4 may result in some
5314 increases in regional economic effects of commercial fishing activities if increases in commercial
5315 fishing catch occurs.

5316 **OTHER SOCIAL EFFECTS**

5317 **Non-Tribal**

5318 Because MO4 is likely to benefit some commercially important anadromous fish populations
5319 compared to the No Action Alternative in Regions B, C, and D, MO4 may result in some
5320 beneficial social effects, if the level of commercially caught anadromous fish increases under
5321 this alternative.

5322 **Tribal**

5323 MO4 is likely to result overall in minor to moderate benefits to anadromous fish populations of
5324 importance in ceremonial and subsistence fisheries compared to the No Action Alternative in
5325 Regions B, C, and D. As a result, MO4 may result in some beneficial social effects, if the level of
5326 fish caught in tribal ceremonial and subsistence fisheries increases.

5327 However, MO4 may result in minor to major adverse effects on resident fish species of
5328 ceremonial and subsistence importance to tribes across all regions. In Region A, increased
5329 entrainment and reduced habitat and food availability under MO4 may result in moderate to
5330 major adverse effects for species such as bull trout, westslope cutthroat trout, and Kootenai
5331 River white sturgeon. In Region B, bull trout, kokanee, rainbow trout, and burbot could
5332 experience adverse effects due to increased entrainment risk. In Region C, bull trout and other
5333 resident fish may experience adverse effects due to increased gas bubble trauma. Finally,
5334 increased TDG and reduced habitat availability may adversely affect resident species in Region
5335 D. To the extent that these effects result in decreased catch of resident fish in ceremonial and
5336 subsistence fisheries, MO4 has the potential to adversely affect the social and cultural benefits
5337 tribes derive from resident fish species through ceremonial and subsistence fishing activities.

5338 **SUMMARY OF EFFECTS**

5339 Because MO4 is likely to result in moderate benefits to anadromous fish populations of
5340 importance in commercial and ceremonial and subsistence fisheries compared to the No Action
5341 Alternative, MO4 may result in moderate beneficial socioeconomic effects, if the number of fish
5342 caught in these fisheries increases. However, moderate to major adverse effects to resident fish

5343 species under MO4 may result in moderate to major adverse effects on the value derived from
5344 ceremonial and subsistence fisheries for those species.

5345 **3.15.4 Tribal Interests**

5346 As stated in the Affected Environment section and emphasized throughout Section 3.5, fish are
5347 of great cultural importance to tribes in the study area and have fundamental roles in diet,
5348 medicine, and cultural identity. For virtually all tribes in the region, fish are part of the history of
5349 subsistence and important to public health. The CRS dams are viewed by tribes as an
5350 impediment to the aquatic resources that are essential to the tribal way of life. For example,
5351 the Lower Snake River dams are seen to adversely impact tribes that rely on the Snake River
5352 aquatic resources.

5353 Each tribe has a personal, cultural, spiritual and commercial connection with the rivers around
5354 them. For instance, the Kootenai Tribe of Idaho and *Yaqaan Nukiy*, the main source of
5355 subsistence historically was fishing. The Kootenai River itself became part of the Tribe's identity
5356 and historically there were a number of camp locations along the River such as at Jennings,
5357 Montana. This is similar for all tribes and their connection to their surrounding rivers.

5358 The fish analysis (Section 3.5) evaluates how MOs impact adult and juvenile anadromous and
5359 resident fish in the study area. In terms of how that would impact Tribal Interests, the analysis
5360 assumes that improved fish conditions would result in more fish available for harvest and, in
5361 general, would lead to socioeconomic benefits. As a result of differing environmental conditions
5362 based on geographic location, and the relative importance of individual fish species, not all
5363 tribes would experience these benefits equally.

5364 In general, however, the analysis describes the following effects.

5365 **3.15.4.1 Salmon, Steelhead, and other Anadromous Fish**

- 5366 • Upper Columbia River salmon and steelhead would see similar or minor increases in
5367 juvenile and adult returns for MO1, MO3, and MO4. Tribal members that harvest these
5368 populations in ceremonial and subsistence or commercial fisheries may see an increase in
5369 numbers of fish return, except under MO2. MO2 would result in decreased abundance for
5370 these fish.
- 5371 • Snake River salmon and steelhead would generally see minor improvements under MO1,
5372 although minor adverse effects to sockeye salmon and fall Chinook salmon may occur. MO2
5373 would result in decreases in juvenile survival and adult abundance would also decrease.
5374 MO3 would have short-term construction related effects but could lead to long-term
5375 increases in adult returns, especially for Snake River Chinook salmon and steelhead. MO4
5376 may result in minor long-term beneficial effects on Chinook salmon and steelhead. Tribes
5377 that rely upon these fish species for commercial or ceremonial and subsistence harvest may
5378 experience impacts corresponding to the nature and extent of impacts anticipated for these
5379 species under each alternative.

5380 **3.15.4.2 Resident Fish**

- 5381 • Region A: MO1 would have minor to moderate adverse effects on bull trout Kootenai River
5382 white sturgeon, and burbot. MO3 would have riparian and sturgeon recruitment effects in
5383 the Kootenai River as well. MO2 and MO4 would have moderate to major adverse effects in
5384 the same areas. Commercial and ceremonial and subsistence fisheries that depend upon
5385 these species may be affected if these impacts result in reduced availability of fish for
5386 harvest.
- 5387 • Region B: MO1, MO2, and MO4 would have moderate adverse effects to resident fish in
5388 Lake Roosevelt stemming from increased entrainment, varial zone effects (important for
5389 migration) and in the river reach, there would be minor reduction in sturgeon recruitment.
5390 MO3 would have increased recruitment and connectivity for sturgeon in McNary Reservoir
5391 with minor short-term construction-related adverse effects. To the extent that these
5392 adverse effects result in fewer resident fish available for harvest, tribal commercial and
5393 ceremonial and subsistence fisheries may be affected.
- 5394 • Region C: MO1, MO2, and MO4 result in adverse effects to resident fish due to warmer
5395 summer water temperatures, reduced flows, increased entrainment, or increased TDG and
5396 GBT. MO3 would result in long-term benefits for bull trout and white sturgeon. Tribes that
5397 harvest these species for commercial and ceremonial and subsistence purposes may see
5398 beneficial effects under MO3, but may be adversely affected under other alternatives.
- 5399 • Region D: Under MO1, resident fish may see minor adverse effects due to warmer summer
5400 water temperatures, reduced flows, or increased TDG and potential for gas bubble trauma.
5401 MO2 and MO3 pool increases at John Day increases white sturgeon habitat but may
5402 increase stranding. Under MO4, increased TDG and reduced habitat availability may
5403 adversely affect resident fish species. The tribes that rely upon these species for commercial
5404 and ceremonial and subsistence harvest may experience similar effects, should the impacts
5405 to fish result in changes in the availability of fish for harvest.
- 5406 All of these fish have economic, subsistence and cultural importance for tribes, and as shown,
5407 effects vary across the study area depending on species.

5408 **3.16 CULTURAL RESOURCES**

5409 **3.16.1 Introduction and Background**

5410 Cultural resources include the entire spectrum of objects and places, from artifacts to cultural
5411 landscapes, and will be analyzed here without regard to importance or their eligibility for
5412 inclusion in the National Register of Historic Places (NRHP), any state register (such as the
5413 Washington Historical Register), or local registers or designations. For the CRSO EIS, cultural
5414 resources are grouped into three property-based categories: archaeological sites, TCPs, and
5415 historic built resources. Archaeological sites include both precontact and historic-period
5416 recorded sites. TCPs are locations of cultural importance to a community, be it a Native
5417 American tribe, a local ethnic group, or the people of the nation as a whole. Built historic
5418 resources are known buildings, structures, and objects within the study area that are more than
5419 50 years old. Pursuant to Executive Order 13007, the co-lead agencies contacted 19 tribes to
5420 request their assistance in identifying sacred sites within the study area, which are evaluated as
5421 a cultural resource. Sacred sites have a unique definition in E.O. 13007 based on tribal religious
5422 beliefs and practices and are not necessarily associated with archaeological sites nor a result of
5423 economic activities. More information on sacred sites is presented in section 3.16.2.7.

5424 Since the 1930s, the co-lead agencies have been working to address the effects of reservoir
5425 operations and maintenance on property-based cultural resources. The pace of this work
5426 picked up in the 1990s, and since then, the co-lead agencies have worked together to identify
5427 cultural resources, evaluate effects, and resolve effects to properties affected by the Columbia
5428 River dams. To date, more than 150,000 acres have been inventoried, hundreds of traditional
5429 cultural properties (TCPs) have been identified, and multiple built historic resources and over
5430 4,500 archaeological sites have been recorded (FCRPS 2019). This work is currently coordinated
5431 and consulted on under the provisions of the *Systemwide Programmatic Agreement for the*
5432 *Management of Historic Properties Affected by the Multipurpose Operations of Fourteen*
5433 *Projects of the Federal Columbia River Power System for Compliance with Section 106 of the*
5434 *National Historic Preservation Act*. More information is available on the FCRPS Cultural
5435 Resource Program website at [https://www.bpa.gov/efw/CulturalResources/FCRPS_Cultural](https://www.bpa.gov/efw/CulturalResources/FCRPS_CulturalResources/Pages/default.aspx)
5436 [Resources/Pages/default.aspx](https://www.bpa.gov/efw/CulturalResources/FCRPS_CulturalResources/Pages/default.aspx)

5437 **3.16.1.1 Area of Analysis**

5438 The CRSO cultural resources study area is the area within which effects to cultural resources
5439 will be considered. For the CRSO EIS it is defined as the 14 dam and reservoir locations and an
5440 area extending 1 mile in all directions from the reservoir full pool elevation to include the
5441 tailrace of each dam. It is anticipated that the 1-mile radius from full pool will encompass all
5442 effects to cultural resources under each alternative. Having a similar area of analysis
5443 surrounding each hydroelectric project will allow for consistent comparison of effects across all
5444 14 projects. Not all lands within the study area, especially permanently inundated and private
5445 lands, have been surveyed for cultural resources.

5446 The co-lead agencies have identified 19 federally recognized Native American tribes that
5447 ascribe cultural importance to various parts or all of the study area. Broadly, most of them can
5448 be grouped into either the Columbia Plateau or Northwest Coast cultural areas. Prior to the
5449 arrival of European Americans approximately 250 years ago, it was both these tribal peoples
5450 and their ancestors who created the precontact archaeological period sites within the study
5451 area. Other peoples and groups with an interest in the cultural resources of the study area
5452 include historians, archaeologists, anthropologists, non-federally recognized tribal groups, and
5453 other concerned citizens.

5454 **3.16.2 Affected Environment**

5455 **3.16.2.1 Ethnohistory**

5456 At first, it was the accounts of early explorers like Lewis and Clark (Thwaites 1904; Meinig 1968;
5457 Dietrich 1995; Durrenberger 1998), fur traders (Ross 1849; Elliot 1914; Tyrell 1916), and settlers
5458 that helped the broader American public become more familiar with tribes and their way of life.
5459 Formal ethnographic research accelerated at the turn of the nineteenth to twentieth century
5460 and has continued into the present (Ray 1936, 1938; Stern 1998; Walker 1998). Today, many
5461 tribes are active in the ethnographic research of their people (Karson 2006; George 2011; Hunn
5462 et al. 2015). A generalized summary of tribal lifeways within the study area at the time of
5463 contact follows.

5464 **SETTLEMENT**

5465 Each tribe occupied a territory that included their living sites and places and areas used for
5466 hunting, fishing, and gathering. Tribal territories and tribal political identities were influenced
5467 by subsistence types and patterns, language, and geography. Tribes' territories included
5468 waterways, such as the Columbia River and its tributaries. Geography and environmental
5469 variety, as well as their particular history, meant that each tribe's territory varied greatly in size
5470 and likely overlapped with their neighbors' territories. The tribes adapted to their territory
5471 through their knowledge and use of local resources, knowledge passed down through
5472 generations. Tribes also adapted to the dynamic environmental patterns on the landscape and
5473 participated in management practices to maintain resources. They were a part of an integral
5474 relationship between the land and culture. Tribal territories include places of spiritual power,
5475 places where religious events took place, and places on the landscape associated with a time
5476 before there were people. For a summary of current tribal concerns please see the tribal
5477 perspectives section 3.17.

5478 People's movements around their territory to make best use of each area seasonally are known
5479 as seasonal rounds. During the winter people generally lived in permanent villages often
5480 located near productive fishing locations. They hunted and gathered resources as available
5481 during the winter season, but it was primarily a time for community and ceremonial gatherings,
5482 storytelling, and intergenerational sharing of knowledge. From spring through fall, smaller
5483 family groups traveled away from the winter village and built temporary structures such as mat
5484 lodges at short-term occupation locations where there were plentiful plant, fish, and game

5485 resources. They also gathered items, such as wood and stone, and traded with others during
5486 these seasonal rounds. This is also the time people went to larger rivers to fish for anadromous
5487 fish, like steelhead and salmon, as they swam upstream to spawn. In addition, root plants were
5488 gathered and prepared for overwintering (Walker and Sprague 1998; Historical Research
5489 Associates, Inc. 2015).

5490 Euroamerican explorers like Lewis and Clark or David Thompson who passed through the Dalles
5491 and Kettle Falls during the early 1800s saw large intertribal gatherings at these important fishing
5492 sites. These gatherings had extended back in time for hundreds, even thousands, of years as
5493 people came together to harvest salmon, trade, and interact with peoples from throughout the
5494 region. Even though all Columbia Plateau groups relied on similar substantive resources, there
5495 were sufficient regional variations to make trade within the Columbia Plateau both desirable and
5496 necessary. In addition to trade within the Columbia Plateau there was interregional trade that
5497 added to the variety of goods used in the region. Traditional trading partnerships were
5498 reinforced by systematic intermarriage, travel by horse, regular trade fairs, and regional
5499 economic specialization. This traditional system of trade formed the basis for the later fur trade,
5500 which enriched an already established system (Stern 1993; Walker and Sprague 1998).

5501 The seasonal round pattern resulted in a variety of archaeological site types, TCPs, and material
5502 assemblages present within the study area. Site types considered in the analysis of this EIS are
5503 presented in Section 3.16.2.2, *Archaeological Site Types*.

5504 **SUBSISTENCE**

5505 For much of the Columbia River Basin region, the various predictable and abundant runs of
5506 salmon, steelhead, and bull trout made up the bulk of protein in people's diets. But since this
5507 particular resource declines in both nutritional value and availability as distance from the ocean
5508 increases, variation in its dietary importance did exist (Historical Research Associates, Inc. 2015).
5509 Not coincidentally, the importance of ungulates, such as deer, antelope, and elk, in the diet
5510 increased with the declining availability of salmon. Fishing was a predictable source of food, with
5511 annual variations in the quantity of fish available. Hunting, however, was not as reliable as a
5512 hunter may invest considerable time searching for prey with an unpredictable return for the
5513 effort (Hayden and Mathewes 2009; see also Patterson et al. 2005; Hay et al. 2007).

5514 Fishing occurred throughout the Columbia River region, but larger groups of people from
5515 different regions gathered annually at specific areas of abundance (e.g., Celilo Falls, Kettle Falls)
5516 to harvest and trade. The timing of the runs of anadromous fish was carefully tracked so groups
5517 of people could be sent to harvest and process large numbers of fish at the migratory choke
5518 points. The productivity of some fisheries was so great that it provided both for residents'
5519 needs and those of visiting communities. Such co-exploitation by multiple groups at these rich
5520 resource sites provided an opportunity for intergroup exchange. Such exchanges were not
5521 limited to the trading of material objects, but included interband marriage, sporting
5522 competitions, development and continuation of commercial relationships, forging alliances
5523 among distant communities, and dissemination of skills and knowledge among communities.

5524 In addition to fishing and hunting, many tribes relied on plants found in various environments.
5525 Bulbs, roots, and corms such as camas, lomatia, bitterroot, and wapato not only provided the
5526 principal source of carbohydrates, dietary fiber, and the bulk of calories in traditional diets, but
5527 were the most reliable resource that could be attained in large quantities (Hunn 1990). Added
5528 to these food resources were various flowering fruits (e.g., huckleberry, serviceberry,
5529 chokeberry) and nuts that people consumed both in season and as overwinter provisions.

5530 **HABITATION AND MATERIAL CULTURE**

5531 For at least the last 5,000 years, there have been permanent winter villages and temporary
5532 resource gathering short-term occupation locations in the Columbia River Basin. The winter
5533 villages usually had semi-subterranean earthen lodges or pithouses along main rivers. The
5534 oblong lodges varied in depth and diameter depending on the number of people living in them.
5535 Winter villages also had associated special-purpose use sites such as cemeteries, food caches,
5536 and specialty work areas. Resource gathering short-term occupation locations had mat-covered
5537 lodges at higher elevations, located near specific resources (Walker 1998; Historical Research
5538 Associates, Inc. 2015).

5539 Intermixed within the residential structures were work areas for manufacturing and
5540 maintaining tools for family needs and wants. Archaeological investigations of sites that date
5541 from the late precontact period and into early historic times have documented changes in the
5542 tool collections of residential sites, harvest areas, and quarry locations. Changes had begun
5543 before Meriwether Lewis and William Clark's visit to the region in 1805, but increased
5544 substantially as European American traders moved into the region. The Hudson's Bay Company
5545 brought many changes to Columbia Plateau culture (Historical Research Associates, Inc. 2015).
5546 Their traders introduced metal knives, guns, manufactured clothes and blankets, new forms of
5547 fishhooks and nets, new paints and dyes, traps, and jewelry that were adopted and adapted
5548 into Native households. Houses also shifted from large multi-family dwellings to smaller single-
5549 family ones typical of European Americans (Walker and Sprague 1998, 144; Historical Research
5550 Associates, Inc. 2015).

5551 **3.16.2.2 Archaeological Resource Types**

5552 For the purposes of the CRSO EIS there are 18 archaeological resource types that will be
5553 examined. These site types encompass both precontact and historic-period sites, including ruins
5554 of built resources. Site types and descriptions follow in Table 3-286. Table 3-287 shows if the
5555 site types are present in the study area, by project, and includes both sites on dry land and
5556 those that are inundated. Single archaeological resources may represent an event, occupation
5557 or activity; groupings of sites can form an archaeological district that is linked by a geographic
5558 boundary, time, or a common theme.

5559 **Table 3-286. Archaeological Resource Types and Descriptions**

Site Type	Description
Agriculture	Archaeological remains of a designed landscape (e.g., shelter belts, orchards) or ranch/farm features (e.g., stock pens, corrals, fences, canal or irrigation features).
Burial/Cemetery	Sites having remains of burials and associated funerary remains that are not part of a short-term occupation location or village. There may be cairns and a small number of artifacts associated with the site. Historic-period burials may or may not contain headstone grave markers.
Rock Cairn	A stacking of rocks that may serve several purposes, both utilitarian and spiritual.
Short-Term Occupation Locations	Short-term occupation site containing artifacts of one or more types and features representing residential use. May include petroglyphs and burials.
Debris Scatter	Refuse scatter, can scatter, refuse deposit, landfill, or debris pit that is greater than 50 years of age.
Industry	Archaeological remains of mining, logging, or other industrial activities. Properties that are greater than 50 years of age no longer in use and not functioning. Can include residential camps and administrative buildings associated with the industry.
Isolated Find	A small number of artifacts found together, with the number being so small it does not meet the state definition of a site; or an isolated feature with no artifacts.
Lithic Scatter	A collection of stone artifacts that are either tools or waste related to the manufacture of tools that is not otherwise related to one of the site types.
Object	A material thing that can be seen and touched and is part of the archaeological record. An object is associated with a specific setting or environment. Historic period items that include historic markers, benchmarks, wagon frames, car parts, machinery, or similar large things.
Resource Procurement/ Processing	Area associated with procurement of tool or food resources (e.g., stone quarry, fishing station, shell midden, etc.), or preparation of those resources for use, that is non-residential in nature. Includes historic-period sites (e.g., tree stands, fishing platforms, mining, logging, etc.).
Rock Images/ Inscription	Precontact paintings or carvings on stone, may be associated with small artifact scatters. Also includes historic-period inscriptions, painting, graffiti, carvings (e.g., surveyors marks, signs, dendroglyphs ^{1/}) on stone, trees, etc.
Rock Feature	Site is primarily consisting of an assemblage of rocks that cannot be grouped into a specific site type. Can include alignments or walls.
Rock Shelter	Rock overhang used for shelter or storage that may have associated artifacts/ features.
Structure	Can include the archaeological remains of a residential base (e.g., homestead, house, cabin, etc.) or military, Corps, and other agency resource management structures (e.g., ranger station, lookout, etc.); churches; stores; and ruins of bridges, pilings, abutments, footings, railroads, roads, or shipwrecks that are greater than 50 years of age.
Talus Pit	A pit dug within an accumulation of rock debris on a slope or at the base of a slope. Pits are frequently used for storage.
Trail/Road	Trail, path, or path segment that appears to be human used/constructed. If the trail is a component of another site type (e.g., Industry), that other category is used.
Unknown	Site consisting of features, usually lacking artifacts, where function cannot be assigned to other categories due to lack of information.
Village/Townsite/ House Pit Depression	Larger site or cluster of dwellings/house pits, usually indicating repeated use over long periods of time. May also contain rock images, burials, etc.

5560 1/ A dendroglyph is an image or design carved into the bark of a tree.

5561 **Table 3-287. Presence of Archaeological Site Types in the Study Area by Project**

Site Type	Bonneville	The Dalles	John Day	McNary	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Dwors hak	Chief Joseph	Grand Coulee	Albeni Falls	Libby	Hungry Horse
Agriculture	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Burial/Cemetery	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Rock Cairn	X	X	X	X	-	X	X	X	-	X	X	-	-	-
Short-Term Occupation Locations	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Debris Scatter	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Industry	X	-	-	-	X	X	-	X	X	X	X	X	X	-
Isolated Find	X	X	X	X	X	X	X	X	X	X	X	-	-	X
Lithic Scatter	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Object	-	-	-	-	X	X	-	X	-	-	X	-	-	-
Resource Procurement/ Processing	X	X	X	X	X	-	X	X	X	X	X	X	X	-
Rock Images/ Inscription	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Rock Feature	X	X	X	X	X	X	X	X	X	X	X	-	-	-
Rock Shelter	X	X	X	X	X	X	X	X	X	X	X	-	-	-
Structure	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Talus Pit	X	X	X	-	-	X	X	X	-	X	X	-	-	-
Trail/Road	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Unknown	-	-	-	-	-	-	X	-	-	X	-	X	X	-
Village/Townsite/ House Pit Depression	X	X	X	X	X	X	X	X	X	X	X	X	X	-

5562

5563 **3.16.2.3 Precontact**

5564 The archaeological record of the Columbia Basin spans a period of about 13,000 years. There is
5565 no single cultural chronology, or identified timeline of events or period and occurrences of site
5566 types, of the basin as a whole. Rather chronologies have been developed for specific research
5567 purposes for particular sites, reservoirs, or subdrainages. The information presented below is a
5568 generalized chronology of the prehistory of the Columbia Plateau, and it will differ slightly with
5569 each specific location. For additional information and description of the precontact period,
5570 please see Browman and Munsell (1969); Reid (1995); Ames and Dumond (1998); Ames et al.
5571 (1998); Chatters and Pokotylo (1998); Pokotylo and Mitchell (1998); Roll and Hackenberger
5572 (1998); Andrefsky (2004); Prentiss et al. (2005); Pouley (2008); Davis, Willis, and Mcfarlin
5573 (2012); and Lyman (2013). Archaeological sites from all the periods described below have been
5574 found within the study area.

5575 **EARLY PERIOD, 9000 TO 6000 B.C.**

5576 People of the Early Period were highly mobile foragers, lived in small groups, and subsisted on a
5577 variety of seasonal foods. In the Southern Plateau, salmon was plentiful, but in the Northern
5578 Plateau people relied more on large fauna. People lived in small, short-term occupation
5579 locations that were moved frequently. Evidence from the middle Columbia region shows
5580 conical-shaped, tipi-like structures were used. There is also evidence of the use of windbreaks
5581 and huts (Binford 1980; Chatters 1986; Ames 1988; Ames et al. 1998; Chatters and Pokotylo
5582 1998).

5583 Stone tools during this period included project points, specifically dart points or spear tips, with
5584 wide bases relative to blade size. Some show edge grinding of the stems, the area of the point
5585 near the base. These points would have been used on the ends of spears for thrusting or darts
5586 for throwing at game using a dart-thrower called an atlatl. The blade shapes and sizes were
5587 highly variable because of resharpening and reuse. Early Period sites consistently had
5588 assemblages of scrapers, for cleaning hides, and flake tools quickly made from stone flakes
5589 without much further modification. In the Southern Plateau small milling stones, manos, and
5590 edge-ground cobbles have been found, indicating the plants were being ground. Artifact
5591 collections also include weighted nets, harpoons, bolas (a weapon with stones tied to multiple
5592 cords), and delicate bone needles indicating the use of tailored leather clothing (Ames et al.
5593 1998; Chatters and Pokotylos 1998).

5594 **MIDDLE PERIOD, 6000 TO 2000 B.C.**

5595 The Middle Period started very similar to the previous Early Period, with people living in small,
5596 mobile, short-term occupations. They hunted and fished, but also started to really use roots,
5597 such as camas, which is evident from the increased number of earth ovens found at
5598 archaeological sites. New styles of projectile points were also introduced, possibly from the
5599 migration of people from outside the Plateau. People relied more upon salmon and other
5600 marine species, making up about 40 percent of their diet, with animal hunting and plant
5601 gathering making up the remainder. As the Middle Period progressed, people started to live a

5602 less mobile lifestyle. Small hamlets of one to three pithouses, living structures partially dug
5603 below surface ground level, appeared. Along with a more sedentary lifestyle came a decrease in
5604 seasonal field short-term occupation locations and an increase in storage pits at sites, showing
5605 use of a more diversified diet that was readily available near main habitation short-term
5606 occupation locations. There was also an increase in trade for obsidian and exotic materials used
5607 to make stone tools, pipes, and beads (Ames et al. 1998; Chatters and Pokotylos 1998).

5608 **LATE PERIOD, 2000 B.C. TO A.D. 1720**

5609 By 2000 B.C., the shift from a mobile forager lifestyle to a storage dependent and sedentary
5610 collector strategy was well underway. Decreased temperatures brought an abundance of
5611 salmon to the rivers and an increased reliance on marine resources. Up to 50 percent of the
5612 diet was from marine resources, but there was also an increase in the use of roots, with large
5613 root processing earthen ovens and large mortars being used at sites. Temporary short-term
5614 occupation locations in river valleys were used for fish, game, root, and mussel acquisition.
5615 Large settlements, with upward of 100 pithouses, have been found along the lower reaches of
5616 rivers. The houses themselves tended to be smaller than in previous time periods, with an
5617 intensification of storage and salmon processing areas. A greater variety of stone tools were
5618 used, bow and arrow technology appeared in this area, and portable art and trade goods,
5619 including shells, beads, steatite pipes, clubs, and elaborately carved implements and ornaments
5620 of stone, whalebone, and antler increased. Rock art began to appear, possibly to identify band
5621 territories or serve other functions. There is also direct and indirect evidence of intergroup
5622 conflicts, with the fortification of mesas and the presence of sites and storage facilities in highly
5623 defensible locations. Social inequality is evident in the varied house sizes as well as the variety
5624 of exotic goods. This inequality probably created or amplified the demand for exotic goods and
5625 art objects (Ames et al 1998; Chatters and Pokotylos 1998).

5626 **3.16.2.4 Historic Period**

5627 The historic period began with the introduction of European American influences with the first
5628 contact of non-Native American people. The impact of the horse, epidemic diseases, trade
5629 goods, missionaries, and fur traders was felt throughout the Columbia River Basin.

5630 For additional information and description of the historic period please see Historical Research
5631 Associates, Inc. (2015), or Walker (1998).

5632 **EURO-AMERICAN EXPLORATION**

5633 In May 1792, Robert Gray became the first European American to record seeing the mouth of
5634 the Columbia River. Non-Native use of the mouth of the Columbia rapidly accelerated after this,
5635 and by 1800, over 100 ships had entered the mouth to trade with Native inhabitants. In 1805
5636 the Corps of Discovery (also known as the Lewis and Clark Expedition) reached the Columbia
5637 River estuary. The route of the Corps of Discovery took them through the present-day locations
5638 of the Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John
5639 Day, The Dalles, and Bonneville dam and reservoir projects and provides some of the earliest

5640 written accounts and maps of the study area. As the first U.S. Government–sponsored cross-
5641 continent expedition, the Corps of Discovery traveled with three related goals: exploration,
5642 trade, and the formation of political alliances with Native American groups. The journals of
5643 Lewis and Clark record the geography and environment through which the Corps of Discovery
5644 traveled, as well as their observations and interactions with various Native Americans
5645 encountered during their journey. The Corps of Discovery reached the Snake River in October
5646 1805 and first saw the Columbia River on October 16 of that year. They traveled down the
5647 Columbia and established their winter camp at Fort Clatsop near the mouth of the Columbia
5648 River. After wintering, they traveled back up the Columbia River on their way back to St. Louis
5649 (Meinig 1968; Moulton 1988; White 1991; Beckham 1995; Dietrich 1995; Schwantes 1996;
5650 Durrenberger 1998; Rochester 2003).

5651 The explorers, as well as the settlers who followed, brought new trade goods and horses, and
5652 introduced new diseases, such as smallpox, measles, and influenza. The Native Americans had
5653 not been previously exposed to these diseases and did not have natural immunity or ways to
5654 treat them. Given this, the diseases had a devastating effect on the population (Beckham 1995;
5655 Walker and Sprague 1998).

5656 **FUR TRADE**

5657 The fur trade dominated the non-Native economy of the Columbia River Basin for the first half
5658 of the nineteenth century. It owes its rapid growth, in part, to its integration with the already
5659 functioning traditional Native American trade system that linked people throughout the
5660 American West. Trade centers, such as The Dalles and Kettle Falls, saw large intertribal
5661 gatherings. This traditional system of trade formed the basis for the fur trade (Beckham 1995).

5662 Manufactured goods brought by the fur traders were frequently embraced by Native
5663 Americans. The fur traders introduced glass beads, woolen blankets, metal tools, firearms,
5664 cotton cloth, and other items that the Native Americans modified or adapted to be useful in
5665 new ways. In exchange European Americans purchased furs from the Native Americans
5666 (Beckham 1995; Walker and Sprague 1998).

5667 Two British companies, the Northwest Company and the Hudson’s Bay Company, competed to
5668 control the fur trade throughout the British territory in North America. Kootenay House,
5669 Flathead House, Spokane House, and Fort Nez Perce were established by the Northwest
5670 Company and Fort Colville and Fort Boise was established by the Hudson’s Bay Company in the
5671 region. The Northwest Company controlled the trade in the Columbia River Basin until it
5672 merged with the Hudson’s Bay Company in 1821. With the merger, the Hudson’s Bay Company
5673 inherited Flathead House, Spokane House, and Fort Nez Perce. The Hudson’s Bay Company
5674 entered into new ventures as beaver pelts lost economic value. These included the production
5675 of grain, livestock husbandry, commercial logging, blacksmithing, and mining. By the 1840s the
5676 Hudson’s Bay Company had moved northward and abandoned its Columbia River holdings
5677 (Simpson 1847; Caywood 1967; Meinig 1968; Ross 1975; Emerson 1994; Dietrich 1995; Walker
5678 and Sprague 1998; Lang 2015).

5679 **MISSIONARIES**

5680 While the fur trade and exploration brought changes to the clothing, technology, and trade of
5681 the Native Americans in the region, the advent of Christian missions ultimately had a larger
5682 impact. The missionaries' impacts were not so much in the changing of Native religious
5683 practices, as much as bringing the European American settlement and lifeways to the region
5684 (Beckham 1995). Missionaries played an important role in the settlement of the Pacific
5685 Northwest by bringing European Americans to the region, but also because they lived alongside
5686 the Native Americans. In addition to the missionaries coming to the region and establishing
5687 missions, there were delegations of Native Americans who went east to learn Christian and
5688 European American ways (Walker and Sprague 1998). The remains of some of the missions are
5689 within the study area, but the impacts of the missionaries are much farther reaching.

5690 In 1834, Methodist minister Jason Lee set out for the Columbia River with a party of four
5691 American men and fur trader Nathaniel Wyeth. Upon reaching Fort Vancouver, Lee decided to
5692 establish a mission in the Willamette River valley. He later established a mission near Five Mile
5693 Rapids and Celilo Falls. From the Wascopam Mission, Lee and various other ministers labored to
5694 preach the work of God, but also practiced agriculture, planted a large garden, and introduced
5695 cattle to the area. Other missionaries who established missions included the Whitmans at
5696 Waiilatpu on the Walla Walla River, the Spaldings near Lapwai on the Clearwater River, and
5697 Mengarini and Point who established the Sacred Heart Mission among the Coeur d'Alenes and
5698 St. Mary's Mission in the Bitterroot Valley of Montana (Beckham 1995; Dietrich 1995;
5699 Schwantes 1996).

5700 As time went on, missionaries increasingly focused on promoting European American
5701 settlement in the territory over converting Native Americans to Christianity. They wanted the
5702 tribes to embrace a more European American lifestyle, primarily by practicing agriculture,
5703 especially grains and fruit trees, and livestock husbandry (Beckham 1995). While there were
5704 some positive aspects of these interactions between missionaries and tribes, it is also important
5705 to note that missionaries sometimes contributed inadvertently to the spread of European
5706 diseases to which few Native Americans had immunity. Estimates of the Native American
5707 depopulation due to disease range as high as 60 to 90 percent (Campbell 1989).

5708 **TREATIES**

5709 The Organic Act of 1848 established the Oregon Territory and the Organic Act of 1853 created
5710 the Washington Territory. Governor Stevens was the new governor of the Washington Territory
5711 and the Superintendent of Indian Affairs for the region. His goals for Indian administration
5712 included securing treaties with the tribes, reserving a few tracts of good land for the tribes,
5713 fostering an agricultural program, and encouraging amalgamation of small bands under a few
5714 chiefs on the reservations. Governor Stevens launched his treaty program in 1854 in western
5715 Washington, then moved east of the Cascades in June 1855, where he was joined by Joel
5716 Palmer, Superintendent of the Oregon Territory. Stevens pressed for agreements with the local
5717 tribes and negotiated three separate treaties in Walla Walla in June 1855; one treaty with the
5718 Cayuse, Umatilla, and Walla Walla; a second treaty with the Nez Perce Tribe, and a third treaty

5719 with the and Yakama Tribes. The Treaty of Hellgate was negotiated in July 1855 with Bitterroot
5720 Salish, Pend d'Oreille, and Kootenai Tribes. Palmer negotiated the Treaty of 1855 with the
5721 Wasco (Warm Springs). The treaties ceded lands, created reservations, provided for agricultural
5722 and educational programs, reserved fishing rights, and protected hunting, gathering, and
5723 grazing rights. None of the tribes to the north of Yakima in central Washington and northern
5724 Idaho participated in the treaties with the United States. Additional reservations in the study
5725 area were formed by executive orders. Some of these executive orders retained tribal rights
5726 similar to the treaties, while others were more restrictive (Ruby and Brown 1972; Beckham
5727 1995, 1998; Walker and Sprague 1998; Confederated Salish and Kootenai Tribes of the Flathead
5728 Reservation 2019; Confederated Tribes of the Warm Springs 2019).

5729 The treaty program thus provided an incomplete settlement with the tribes of the Columbia
5730 River Basin. Some tribes and bands secured ratified treaties with specific reserved rights. Others
5731 participated in councils but never secured ratification of their agreements. Still other tribes and
5732 bands remained outside of the treaty process altogether. These inconsistencies, the continued
5733 trespass of European American settlers, and the influx of miners and cattle drovers set the
5734 stage for the Indian Wars, which beset these people in the middle of the nineteenth century
5735 (Beckham 1995).

5736 **SETTLEMENT**

5737 In 1843, missionary Marcus Whitman led 1,000 Americans along the Oregon Trail, in what
5738 became known as the Great Migration. The overland route effectively ended at The Dalles,
5739 where the pioneers would raft down the Columbia River to Fort Vancouver and into the
5740 Willamette Valley (Dietrich 1995; Schwantes 1996). Within a few years the number of
5741 immigrants arriving tripled to about 3,000 per year (Beckham 1995). In 1849, the War
5742 Department dispatched the Overland Rifleman, a contingent of the U.S. Cavalry, to cross the
5743 Oregon Trail and establish military posts to ensure peaceful relationships between Native
5744 Americans and settlers (Beckham 1995).

5745 Towns were established near existing army posts as well as in other rural areas. They were
5746 often arranged linearly up streams and creek beds in the best agricultural land and were
5747 densely settled. Beyond the prime agricultural plots, more thinly occupied regions developed
5748 (Meinig 1968). The U.S. Government actively encourage westward migration of European
5749 Americans through a series of land settlement acts passed by the Congress. The Donation Land
5750 Claim Act of 1850 lead to the early European American settlement of the Oregon Territory,
5751 which included modern day Washington State, with the promise of 160 acres of free land to
5752 settlers. Many prime pieces of land in the Columbia Gorge and elsewhere in the study area
5753 were settled under the act (Beckham 1995; Riddle 2010). The Indian Treaty Act of 1851
5754 authorized the use of funds to negotiate treaties with Indian tribes and bands. The intent was
5755 to settle potential claims by Indians to the land through the treaties (Bennett 2008).

5756 In 1862, Congress passed the Homestead Act, that allowed any citizen or alien who declared
5757 their intention of becoming a citizen, and who was head of a family and over 21 to claim 160
5758 acres of land from the surveyed portion of the public domain. This also meant women, many of

5759 whom were widowed during the Civil War, were eligible for tracts of land. In 1880, Congress
5760 extended the act to include portions of the public domain yet to be surveyed. After residing on
5761 this land, adding improvements, and paying a small registration fee, homesteaders would
5762 become the owner (Bruce 2001). Between 1862 and 1890, 372,659 homesteads were claimed
5763 through the Homestead Act. By 1940, homesteads occupied 285 million acres of formerly public
5764 land (Gilbert 1968; Bruce 2001; White 1991). Within the study area, the remains of these
5765 homesteads can be seen as buildings, foundations, gardens, and irrigation ditches and other
5766 archaeological features.

5767 **U.S. GOVERNMENT AND SETTLEMENT IMPACTS TO TRIBES**

5768 The complex history of U.S. Government policies and settlement had varied, profound, and
5769 long-lasting effects on every aspect of tribal life. Before Euro-American settlers arrived in the
5770 region, their presence on the North American continent entailed the arrival in the Pacific
5771 Northwest of European diseases against which the native people had no immunity. There is
5772 some archaeological evidence to indicate that epidemic diseases may have arrived in the region
5773 as early as the 1500s or 1600s after the Spanish came into the American Southwest (Campbell
5774 1989). During the 1770s, outbreaks of small pox are believed to have killed potentially as much
5775 as 30 percent of the tribal population in the Pacific Northwest (Boyd 1994). By the time Lewis
5776 and Clark traveled the Columbia, it was estimated that two different outbreaks of western
5777 disease had decimated the people living along the Columbia River.

5778 The Spanish exploration of the Northwest Coast may have begun as early as the 1540s. In 1707
5779 the first well documented contact occurred with the wreckage of the Spanish galleon San
5780 Francisco Xavier, on the Oregon coast after being blown off course. The Spanish, Russian, and
5781 English did not reach the area to intentionally explore it until the early 1770s. European
5782 contacts at the coast spread disease rapidly inland and disease claimed whole villages. During
5783 the 80-year period from the 1770s to 1850, smallpox, measles, influenza, and other diseases
5784 swept through the region. Epidemics of smallpox appeared every generation: in the late 1770s,
5785 1801-02, 1836-38, and finally (in two separate areas) in 1853 and 1862-63. While a precise
5786 number of people who succumbed to these diseases will never be known, it is accepted that 60
5787 to 90 percent of the tribal population was lost to these diseases (Boyd. 1994).

5788 Concurrent with the outbreaks of diseases, increasing numbers of non-tribal settlers began to
5789 arrive in the region from the 1840s onwards. Before then, contact between the tribes and non-
5790 tribal peoples was limited to fur traders and explorers. Starting in the 1840s, the establishment
5791 of improved and expanded trails saw an influx of non-tribal settlers, who were encouraged to
5792 enter the region by federal policies that promised land to them. In particular, the 1850
5793 Donation Land Claim Act (9 Stat. 496) opened the Oregon Territory, which encompassed almost
5794 the entire Pacific Northwest, to settlement even before treaties with the tribes had addressed
5795 Indian ownership of the land.

5796 While relations between tribal and non-tribal peoples were mostly peaceful, the increasing
5797 numbers of settlers resulted in growing tensions in the 1850s as tribal people found themselves
5798 cut-off from traditional gathering areas, hunting grounds, and village sites, as well as increasing

5799 competition for the region's abundant, but nonetheless, limited resources. These conflicts
5800 prompted the U.S. Government to enter treaty negotiations with many of the tribes. These
5801 negotiations resulted in arrangements through which the tribes ceded large portions of land to
5802 the U.S. Government in return for smaller areas of reserved land and promises of food,
5803 healthcare, education, and tribal governance, among other provisions. After 1871, reservations
5804 were formed by Executive Order. While the reservations were sometimes located on the
5805 ancestral lands of the tribes to whom they were assigned, often the tribes were forced to
5806 abandon their traditional areas and relocate to areas that they had no, or limited connections
5807 to. This relocation severed cultural connections with traditional use areas for food and root
5808 gathering, hunting, habitation, burial, spiritual, and meeting.

5809 The treaties were not entirely successful in resolving the tensions that originally prompted the
5810 U.S. Government to start negotiations. In many cases, the terms were unacceptable to some of
5811 the tribes. In other instances, while treaties were signed, they were never ratified by Congress.
5812 Tension rose in the region due to differences in treaty interpretation, U.S. Government failure
5813 to abide by commitments, and non-tribal population growth. These unresolved tensions
5814 resulted in armed conflict beginning in the mid-1850s between some of the region's tribes and
5815 non-tribal settlers supported by local militias and the U.S. Army. In the Pacific Northwest, these
5816 battles culminated in the Nez Perce War in 1877, which involved Chief Joseph's famous fighting
5817 retreat toward Canada.

5818 The establishment of the reservations did not end the pressure brought by non-tribal settlers
5819 seeking access to tribal land. In 1887, Congress passed the General Allotment Act, also known
5820 as the Dawes Act (24 Stat. 388). This measure, conceived as a means of parceling out
5821 reservation lands to individual tribal members and to be held in trust by the U.S. Government,
5822 had the effect of significantly reducing the amount of land held by tribes. Tribal lands not
5823 allotted to tribal members on the reservation were sold by the U.S. Government to
5824 homesteaders. When the allotment process began in 1887, the total reservation land held by
5825 tribes equaled 138,000,000 acres. By the end of the allotment period, tribal landholdings were
5826 dramatically decreased to about 48,000,000 acres (DeLoria and Salisbury 2004). This policy
5827 resulted in the 'checker-boarding' of reservation land. Land ownership within reservations was
5828 a mix of a larger number of fee-owned private properties, the majority of which were non-tribal
5829 owners, and fewer properties held in tribal trust.

5830 **MINING**

5831 Two major mining rushes occurred in proximity to the study area during the second half of the
5832 nineteenth century: the Colville gold rush (1855) and the Clearwater gold rush (1861). After
5833 Hudson's Bay Company employees found placer gold near Fort Colville in 1855, hundreds of
5834 miners rushed to the upper Columbia River region. The Colville gold rush was relatively short lived
5835 and did not produce a substantial amount of wealth (Tate 2004). In the early 1860s, a gold rush
5836 along the Clearwater River brought prospectors to goldfields that extended from Walla Walla to
5837 the confluence of the Clearwater and Snake Rivers (Lundin and Lundin 2012). The Clearwater gold
5838 rush produced wealth that shaped settlement in the Columbia River Basin from the 1860s up to

5839 the present. Communities boomed in Lewiston, Pierce City, Orofino, and Walla Walla as
5840 thousands of prospective miners traveled to the Clearwater River. By the mid-1860s, the
5841 Clearwater gold rush had run its course. A few of the newly established communities stabilized
5842 and endured as permanent settlements, others were abandoned. The Clearwater gold rush
5843 directly contributed to the reduction of the Nez Perce Reservation from its original 1855 size of
5844 about 7.5 million acres to the post-gold rush size of about 750,000 acres as miners pushed the
5845 government for greater access to reservation lands (Walker 1998). Other mining took place in the
5846 Blue Mountains of Oregon where gold was discovered in 1861, a few miles to the southwest of
5847 Baker City. When the placer mines declined, the quartz mining industry developed in the late
5848 1860s and slowly evolved until another gold and silver boom occurred in 1899. With this new
5849 boom came the development of Baker City as a supply point, the flourishing of mining towns such
5850 as Union and Huntington, and the revival of Sumpter, Oregon. There was gold mining in many
5851 other locations, such as in Hells Canyon and along the Salmon River. In some cases, even gold
5852 rushes outside of the Columbia River Basin had an impact on the study area. For example, a gold
5853 rush occurred in the Fraser River Canyon in the late 1850s. To help feed the booming population
5854 of miners, ranchers drove cattle up the "Cariboo Trail" from Wallula Gap near the confluence of
5855 the Snake and Columbia Rivers to the mouth of the Okanogan River and then up to Canada
5856 (Dorpat and McCoy 1998). Miners who traveled these routes sometimes came into conflict with
5857 tribes, who had not authorized the heavy use and related depredation of these traditional travel
5858 corridors. The McLoughlin Canyon skirmish of 1858 is a well-known example of this kind of
5859 conflict in the region (CTCR 2006). Additionally, there was copper and iron mining in the vicinity of
5860 the Albeni Falls dam and reservoir project (Meinig 1968; Schwantes 1996; Tate 2004; Lundin and
5861 Lundin 2012).

5862 In addition to the gold rushes, there were placer mines up and down the Columbia, Snake, and
5863 Pend Oreille Rivers. Many of the mines were run by the Six Chinese Companies, which
5864 employed Chinese people from the Cantonese countryside who would send money back home
5865 (Evenson 2016). They established large placer mining camps at places such as Marcus and China
5866 Bend along the upper Columbia River. There were also a handful of Chinese owned and
5867 operated merchant stores along the Columbia River and its tributaries. Many of the
5868 settlements, placer mining sites, and the stores that provided supplies have been inundated.
5869 Some remnants of these are now archaeological sites located within the study area, primarily
5870 near the edge of reservoirs.

5871 **AGRICULTURE**

5872 Agriculture and herding within the region were important parts of the economy. Practiced by
5873 Hudson's Bay Company employees, missionaries, and some Native American groups in the
5874 region, herding spread throughout the basin in the early 1860s. Cattle and sheep were the
5875 major species in the region, though people also raised horses, mules, burros, and hogs. The
5876 cattle industry boomed along with the mines in the mid-1860s, then leveled out as the
5877 Clearwater gold rush tapered off and the mining communities raised their own herds in valleys
5878 adjacent to the mines. Exporting to new markets around Puget Sound and in the East, the cattle

5879 industry peaked during the 1870s before being replaced by smaller ranches during the 1880s
5880 (Meinig 1968).

5881 The Hudson's Bay Company introduced subsistence farming to the Pacific Northwest in the
5882 1820s, as the company sought to increase the self-sufficiency of their trading posts.
5883 Missionaries and settlers arriving in the 1830s also brought agricultural methods and cultivars
5884 with them, planting orchards, gardens, and grain on early homesteads along the river valleys.
5885 Similar to the livestock industry, farmers responded to the booming demand for oats and wheat
5886 during the Clearwater gold rush. The early 1860s were marked by increased production of
5887 wheat throughout the Columbia River Basin and agricultural experiments to determine the
5888 optimal planting and growing conditions for the crop. By 1870, agriculture, predominantly
5889 wheat, had become the primary industry in the Columbia River Basin. The construction of
5890 railroads across the region (primarily in the 1880s) furthered industrial growth. The railroads
5891 attracted new settlers and opened up additional routes through which they could export
5892 products to distant markets (Meinig 1968; Pfaff 2002).

5893 **LOGGING**

5894 As with the other major historic-period industries, the Hudson's Bay Company was the first
5895 entity in the Pacific Northwest to conduct commercial logging operations in the Columbia River
5896 Basin. Commercial exports of timber began in 1848 when a mill was established in Oregon City.
5897 By 1850, 37 sawmills had been established in the Pacific Northwest, most near the mouths of
5898 the Columbia and Willamette Rivers. The industry dominated the region during the second half
5899 of the nineteenth century and through the first half of the twentieth century. The remnants of
5900 historic-period logging activities exist today as archaeological sites within several locations of
5901 the study area. These types of sites are mostly located under storage reservoirs in higher
5902 elevation or mountainous terrain such as near Hungry Horse or Libby dam and reservoir
5903 projects. For further information on the history of logging and potential related resources see
5904 Holbrook (1990); Historical Research Associates, Inc. (2016); and Harrison (2008c).

5905 **FISHING**

5906 Salmon fishing has been important to the Native American diet and formed an integral part of
5907 their lives for at least 10,000 years (Hunn and French 1998; Butler and O'Connor 2004).
5908 Sturgeon and lamprey have also been important to the Native Americans of the area. In the
5909 historic period, tribes continued to fish at important locations, such as Kettle Falls and Celilo
5910 Falls as well as other lesser known fishing locations. They established seasonal habitation areas
5911 in these locations and built fishing platforms to make it easier to fish at the falls and rapids.
5912 Remains of these camps can still be found in the archaeological record (Anastasio 1972; Beckam
5913 1998; Hunn and French 1998).

5914 At its peak, fishing was the second largest industry in the Washington and Oregon Territories,
5915 behind the timber industry. The Hudson's Bay Company shipped barrels of salmon to London in
5916 1827, the first recorded fish exported from the Columbia River Basin. Missionaries and other
5917 settlers joined the salt-salmon trade, but they struggled to find ways to store and preserve the

5918 fish being transported to Hawaiian, British, and other distant markets. As methods improved,
5919 salt-salmon fisheries continued to operate in the Columbia River Basin through the 1880s
5920 (Smith 1979; Schwantes 1996). The first salmon cannery was established on the Columbia River
5921 in 1866 and by 1883 there were 43 canneries operating on the river. The last major cannery
5922 shut down in 1980. The commercial canning industry used many methods to catch the salmon
5923 runs, but none were as effective as the fish wheel, which was introduced in 1884. By 1899,
5924 there were 76 fish wheels operating on the Columbia River. Remains of canneries and fish
5925 wheels can be found along the Columbia River (Smith 1979; Petersen and Reed 1994; Harrison
5926 2011; Barber 2018).

5927 **3.16.2.5 Built Environment**

5928 **HYDROELECTRICITY DEVELOPMENT**

5929 Hydroelectricity production was studied early in the 1900s (Harza 1914), and began on the
5930 Columbia River in the 1930s. Today, 49 federal and non-federal hydroelectric dams exist in the
5931 Columbia River Basin (FCRPS 2016). In the early 1920s, the Corps River Basin Survey team
5932 surveyed the Columbia River Basin and devised a plan that would develop the resource
5933 potential of the river along multiple fronts: navigation, flood control (now referred to as flood
5934 risk management), irrigation, and hydroelectric power. The River Basin Survey report laid out a
5935 plan for the construction of 10 multipurpose dams in the Columbia River Basin. President
5936 Franklin D. Roosevelt's administration requested and Congress approved funding for
5937 construction of both the Bonneville Lock and Dam and the Grand Coulee Dam in 1933 as part of
5938 the New Deal, putting thousands of unemployed Americans to work during the Great
5939 Depression. Construction of Bonneville Lock and Dam was completed in 1938. The Grand
5940 Coulee Dam, the largest concrete structure in the world at the time, was completed in 1941
5941 (Bonneville ca. 1980; White 1991; Dietrich 1995).

5942 The principal structures within the study area are the series of Federal dams built and put in
5943 service between 1938 and 1976. Associated structures, such as transmission lines, substations,
5944 and administrative buildings, can be found near the hydroelectric projects. Some of the
5945 structures have not yet reached the 50-year benchmark for consideration as a historic built
5946 environment resource in this section; however, they are eligible for the NRHP as components of
5947 the large-scale Federal civil works undertaking that transformed the Pacific Northwest.
5948 Bonneville Dam has been designated a National Historic Landmark. For a description of the
5949 dams please refer to FCRPS (2016).

5950 **COLUMBIA AND SNAKE RIVER TRANSPORTATION**

5951 Before the nineteenth century travel along the Columbia River was constrained by the river's
5952 fast waters and falls. During the latter half of the nineteenth century, a need to transport
5953 mining and agricultural goods emerged. Steamboats were used to transport goods up and
5954 down the Columbia and Snake Rivers between ports, but at areas of rapids and falls, such as
5955 Celilo Falls and Cascade Rapids, goods had to be offloaded and portaged by foot, wagon, or
5956 train. However in 1896 the Cascade Canal opened, which allowed boats to traverse the area of
5957 Cascade Rapids without the need to offload and portage. In 1915 the Dalles-Celilo Canal

5958 opened, allowing similar access in the area of Celilo Falls (Paulus 2010). With the construction
5959 of the various dams and the inundation of lands, roads and railroad beds had to be relocated
5960 with the old ones being abandoned in place in many cases. The remains of the locks, roads, and
5961 railroad beds still lie in or near the reservoirs (Paulus 2010).

5962 **TRANSPORTATION**

5963 Historic-period occupation and industry in the Columbia River Basin were inseparably linked to
5964 advances in transportation. A network of trails used by Native Americans was already in
5965 existence when the European Americans arrived. These routes, and new ones, were used by the
5966 fur traders and missionaries, laying the way for the Oregon Trail along the south bank of the
5967 Columbia River to The Dalles. Migrants then rafted the river from The Dalles to Fort Vancouver
5968 and the Willamette Valley. The steamboat era took off during the 1850s and 1860s, as European
5969 Americans settled throughout the Columbia River Basin, requiring transportation for themselves
5970 and their commercial exports (gold, wheat, timber). While steamboats provided transportation
5971 along the river, entrepreneurs established and operated ferry crossings to carry people and
5972 goods across the rivers. Remnants of these steamboat and ferry landings still remain within the
5973 study area (Ruby and Brown 1974; Dietrich 1995; Schwantes 1996; Harrison 2008b).

5974 Railroads in the Columbia River Basin were initially designed to facilitate transit around
5975 dangerous rapids on the lower Columbia River. The first railroad, constructed in 1851, consisted
5976 of a portage tramway around the Cascades Rapids, in the present-day vicinity of Bonneville
5977 Dam. By 1862, railroad portages operated on both sides of the Cascades Rapids. In 1853, the
5978 U.S. Army launched a comprehensive examination of the Pacific Northwest as part of the Pacific
5979 Railroads Survey. The purpose of the surveys was to find five alternative routes to bring the
5980 railroad to the Pacific Northwest. The surveys were multi-faceted, involving naturalists,
5981 geologists, ethnographers, and cartographers. Critical to the location of transportation
5982 corridors were the engineers who examined the countryside for grades, curves, tunnels,
5983 bridges, and the technical feasibility of the routes. The Northern Pacific line through the
5984 Columbia River Basin was completed in 1883 and included the construction of the first bridge
5985 across the Snake River, near Pasco, Washington (Meinig 1968; Holbrook 1990; Beckham 1995;
5986 Holstine and Hobbs 2005; Harrison 2008a).

5987 Similar to the railroads, the first wagon road in the region was constructed around the portage
5988 of the Cascades Rapids (Bullard 1982). Other wagon roads were established in the 1830s and
5989 1840s, but it wasn't until 1843 that the first wagons on the Oregon Trail reached Oregon. In
5990 that year an estimated 900 men women, and children and about 3,000 head of livestock
5991 crossed the Oregon Trail (Beckham 1995; NPS 2019b). In 1907, the first public road bridge was
5992 constructed across the Columbia River near Wenatchee, Washington. The rise of the
5993 automobile in the early twentieth century fueled the construction of county roads and state
5994 and interstate highways, as well as a series of related bridges, in the Columbia River Basin
5995 throughout the century. Some of these original railroad beds, roads, and bridges still remain
5996 within the study area (Meinig 1968; Holbrook 1990; Beckham 1995; Holstine and Hobbs 2005).

5997 **URBAN DEVELOPMENT**

5998 Along with the development of the waterways as shipping canals and the various forms of
5999 transportation, urban areas also developed. Along the rivers of the Columbia River Basin
6000 steamboat landings of the 1800s and early 1900s turned into cities as these early ports became
6001 more established. Many of the early cities, such as Hood River, were dependent on resource
6002 extraction, such as logging the forests along both shores of the Columbia River. Built resources
6003 related to urban development may include a variety of residential and commercial buildings
6004 and structures located within the boundaries of established municipalities, towns, and cities
6005 within the study area.

6006 **IRRIGATION**

6007 Irrigation of crops along the Columbia River began with the first permanent settlements along
6008 the river. In 1818, Donald McKenzie of the Northwest Company constructed one of the first, if
6009 not the first, irrigation systems along the Columbia River at the confluence of the Columbia and
6010 Walla Walla Rivers. The system irrigated the gardens of Fort Nez Perce via ditches from the
6011 Walla Walla River. When Marcus Whitman arrived in the area 18 years later, he created the
6012 irrigation system to water the gardens at his Wailatpu mission, approximately 7 miles west of
6013 present day Walla Walla. Other missionaries and forts also created irrigation systems to water
6014 their gardens around the same time (NW Council 2019b).

6015 The first large-scale irrigation project in the Columbia River Basin was built in 1859 in the Walla
6016 Walla River valley. Private irrigation companies were responsible for watering approximately
6017 2.3 million acres in the region by 1910. Social and economic conditions in the United States
6018 during the Great Depression led to a new era of farming and irrigation in the Columbia River
6019 Basin. Small homesteads gave way to larger agricultural ventures, financed by outside investors.
6020 Irrigation projects that were considered too expensive before World War I, such as the
6021 Columbia Basin Project and Grand Coulee Dam, were constructed. From small- to large-scale
6022 projects, the irrigation development was an important part of the development of the Columbia
6023 River Basin and portions of these irrigation projects can still be seen today in the study area
6024 (Meinig 1968; Dietrich 1995; Pfaff 2002; National Research Council 2004). Table 3-288 shows
6025 the built resources by type present in the study area, by project.

6026 **Table 3-288. Presence of Built Environment Resource Types in the Study Area by Project**

Resource Type	Bonneville	The Dalles	John Day	McNary	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Dworshak	Chief Joseph	Grand Coulee	Albeni Falls	Libby	Hungry Horse
Dams/Locks	X	X	X	X	X	X	-	-	-	X	X	X	-	X
Bridges	X	X	X	X	-	X	-	X	X	X	X	X	X	-
Railroad	X	X	X	X	X	X	-	X	X	X	X	X	X	-
Ferry Terminals	-	-	-	X	-	X	-	X	-	-	X	-	-	-
Irrigation Infrastructure	-	?	X	X	-	-	-	-	-	X	X	-	-	-
Recreational Facilities	X	X	X	X	X	-	-	X	X	X	X	X	X	X
Residential	X	X	X	X	-	-	X	X	X	X	X	X	-	X
Commercial	X	X	X	X	-	-	-	X	X	X	X	X	-	-
Port Components	X	X	X	X	-	-	-	X	-	-	-	-	-	-
Military Structures	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Religious Structures	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Power Transmission System	X	X	X	X	X	X	X	X	X	X	X	X	X	X

6027

6028 **3.16.2.6 Traditional Cultural Properties**

6029 TCPs are a type of cultural resources property that is based on its cultural importance to a living
6030 community. A TCP can be defined generally as one that is important because of its association
6031 with cultural practices or beliefs of a living community that (1) are rooted in that community’s
6032 history, and (2) are important in maintaining the continuing cultural identity of the community
6033 (Parker and King 1990). The traditional cultural importance of a property, then, is importance
6034 derived from the role the property plays in the community’s historically rooted beliefs,
6035 customs, and practices. While a TCP must be a tangible property, a culturally recognized natural
6036 landscape or a natural object, such as a rock outcrop, it may be included if it is associated with a
6037 current tradition or use (NPS 1990; Parker and King 1990).

6038 For this EIS, a total of 1,365 TCPs have been identified within the study area for the 14 projects.
6039 Within the study area the TCPs are located in three different broad locational categories
6040 relative to the reservoirs. The TCPs in the study area surrounding each reservoir are either
6041 completely inundated, in the fluctuation zone, or above the fluctuation zone. The fluctuation
6042 zone is the portion of the reservoir that is regulated between full pool and minimum pool.
6043 Table 3-289 shows the distribution of the TCPs relative to each of these zones. For a TCP to be
6044 categorized as permanently inundated, at least 75 percent of the boundary must be below the
6045 elevation of the reservoir fluctuation zone. Properties that are in the fluctuation zone can be
6046 completely within the fluctuation zone; or spanning the fluctuation zone and a portion of the
6047 permanently inundated area; or intersecting the fluctuation zone and the area above the
6048 fluctuation zone (or a combination).

6049 **Table 3-289. Distribution of TCPs**

Project	Completely Inundated TCPs	TCPs in Fluctuation Zone	TCPs above Fluctuation Zone	Total
Bonneville	20	19	81	120
The Dalles	23	17	58	98
John Day	17	63	37	117
McNary	10	141	34	185
Ice Harbor	18	118	2	138
Lower Monumental	11	52	5	68
Little Goose	0	39	1	40
Lower Granite	0	47	7	54
Dworshak	4	9	31	44
Chief Joseph	19	8	31	58
Grand Coulee	183	125	119	427
Albeni Falls	0	0	1	1
Libby	0	0	0	0
Hungry Horse	0	15	0	15

6050 There are seven types of TCPs that will be described in this EIS: hunting areas, fishing sites,
6051 gathering areas, habitation locations, legendary sites, cemeteries, and sites that the co-lead
6052 agencies lack data to characterize. These types are expanded on below.

6053 Hunting areas are traditional areas that were used for hunting, trapping, tracking, or pursuing
6054 animals with the intent to kill them. These are areas that have been used for many generations
6055 and frequently have been named. An example of a hunting area that is a TCP is at the mouth of
6056 Hellgate Canyon on Lake Roosevelt that has been used traditionally, and is still used, as a
6057 hunting location for deer.

6058 Fishing sites are traditional locations where people fish, use fish traps or weirs, or had fishing
6059 platforms. These are areas that have been used for many generations and typically have place
6060 names. Well known examples for fishing locations include Celilo Falls along the lower Columbia
6061 River and Kettle Falls along the upper Columbia River, but fishing sites also include areas that
6062 were less well known and may have been used only by a family or a single tribe.

6063 Gathering areas are traditional places where resources are gathered. Some important plants
6064 gathered include camas and wapato roots, tule used for basket and mat making, and berries.
6065 Other types of resources gathered include stone for making chipped tools, ground tools, and
6066 stone pipes and also places where shellfish are gathered. These places have been used for
6067 generations and are still used today.

6068 Habitation locations are traditional locations where people have lived. These can be large or
6069 small villages or camps used during resource extraction. Frequently these will have cultural
6070 remains, such as foundations, house pits, storage pits, resource preparation areas, or refuse
6071 areas. For a habitation location to be a TCP it would need to be identified by the living
6072 community as a place that was used repeatedly in the past and is still important today for a
6073 similar purpose.

6074 Legendary sites are places with historic and cultural value that are referenced in stories. These
6075 are usually physical features and landscapes, such as rock outcroppings and formations, buttes,
6076 large and distinctive ridges, cliffs, waterfalls, or valleys. An example is a Native American story
6077 about Celilo Falls, which is said to be a dam created by the five swallow sisters to block salmon
6078 from going up stream. Coyote tricked the sisters and broke the dam resulting in salmon being
6079 able to swim upstream. As punishment for keeping salmon from the people, Coyote made
6080 swallows fly upstream each year to announce the arrival of salmon (Hunn et al. 2015; NW
6081 Council 2019a).

6082 Cemeteries are a place where the remains of the dead are interred. Because cemeteries
6083 represent a physical tie between their ancestors and the lands where they live, cemeteries are
6084 seen as being important in the preservation of community identity.

6085 “Agency lacking data to characterize” sites are TCPs that do not fit into the above categories.
6086 Examples of such TCPs include places where wild horses used to run along Grand Coulee, the
6087 mouth of rivers and creeks, trails and roads, locations of rapids in rivers, towns that were
6088 inundated with the construction of dams, and locations of landslides. While there may be
6089 stories associated with some features, such as the landslide that created the Bridge of the
6090 Gods, other similar features do not have a story associated with them and could not be put in
6091 the legendary sites category.

6092 **3.16.2.7 Sacred Sites**

6093 Executive Order 13007 directs that Federal agencies shall accommodate access to and
6094 ceremonial use of Indian sacred sites by Indian religious practitioners, to the extent practicable,
6095 permitted by law, and not clearly inconsistent with essential agency functions. It also states
6096 that Federal agencies will avoid adversely affecting the physical integrity of sacred sites, but like
6097 the provision regarding access, this is subject to restrictions based on practicability, legality, and
6098 essential agency function. Where appropriate, agencies will maintain the confidentiality of
6099 sacred sites. As defined in the Executive Order, a sacred site “means any specific, discrete,
6100 narrowly delineated location on Federal land that is identified by an Indian tribe, or Indian
6101 individual determined to be an appropriately authoritative representative of an Indian religion,
6102 as sacred by virtue of its established religious importance to, or ceremonial use by, an Indian
6103 religion; provided that the tribe or appropriately authoritative representative of an Indian
6104 religion has informed the agency of the existence of such a site” (Clinton 1996). The Executive
6105 Order states agencies with Federal lands are to ensure notification if an action is to affect the
6106 physical integrity of sacred sites or if future access or ceremonial use of a sacred site is to be
6107 restricted.

6108 Pursuant to the Executive Order, the co-lead agencies for the CRSO EIS contacted 19 tribes to
6109 request their assistance in identifying sacred sites within the study area. As a result of this
6110 effort Kettle Falls at Grand Coulee and Bear Paw Rock at Albeni Falls were identified as sacred
6111 sites. Although only two sacred sites were identified in keeping with the definition in the
6112 Executive Order, it is likely that many other sacred sites could be identified as part of
6113 consideration of future projects. Many tribal representatives had concerns regarding
6114 confidentiality and disclosure of sacred sites. Co-lead agencies received information from one
6115 tribal representative identifying all federal lands in the cultural resources study area along the
6116 Columbia and much of the lower Snake rivers as a sacred site. The co-lead agencies believe this
6117 does not meet the definition in the Executive Order as it is not discrete or narrowly delineated.

6118 **3.16.3 Environmental Consequences**

6119 **3.16.3.1 Introduction**

6120 **ARCHAEOLOGICAL RESOURCES**

6121 **Introduction**

6122 Effects on archaeological resources are assessed based on the extent to which an alternative
6123 increases the potential for erosion and other processes that contribute to archaeological
6124 resource damage and decay. Erosion adversely affects archaeological sites by removing human
6125 burials, artifacts, features such as fire hearths and house pits, and other valuable information.
6126 Reservoir draft and refill cycles are the primary sources of erosion at storage pools. Rapid
6127 raising and lowering of a pool can undermine shoreline stability. For sites in the drawdown zone
6128 below full pool, exposure can result in erosion from wind and water runoff (gully and sheet
6129 erosion). Erosion can accelerate in drawdown zones when normally submerged, quickly flowing
6130 rivers reemerge, and when wave action works along temporary banks that form during

6131 drawdowns. Drawdown zones can also affect site integrity by increasing accessibility and
6132 visibility, resulting in site vandalism, looting, and artifact collection. The exposure also increases
6133 the chances of inadvertent damage caused by livestock trampling and recreational activities.

6134 This analysis will look at the frequency, amplitude, and rate of reservoir elevation changes as a
6135 measure of reservoir operations that enhance erosion. In addition, this analysis will consider
6136 the time period that archaeological resources are exposed, given the correlation between
6137 exposure and adverse effects. For all erosion metrics, it is assumed that a stable environment
6138 results in less erosion and decay of archaeological resources over time and is therefore
6139 “beneficial” for archaeological resources, at least in comparison to other alternatives that
6140 feature less stability.

6141 **Methodology**

6142 **Exposure**

6143 Given that exposure of inundated archaeological resource is generally an adverse effect, it is
6144 helpful to have metrics to describe the extent of exposure and thus be able to compare effects
6145 of different alternatives. Two variables need to be considered. First is the time period of
6146 exposure, or the number of days that the drawdown zone is going to be exposed. Second is the
6147 area of the archaeological resources. Archaeological resources can vary in size greatly, from
6148 isolated features covering just a few feet to large village sites that stretch for miles. If an area is
6149 exposed that contains no archaeological resources, that exposure has no consequences for
6150 archaeological resources. On the other hand, if an exposed area does have archaeological
6151 resources, then that exposure does have consequences.

6152 One way to combine these two variables (time and area) for comparison purposes is to multiply
6153 the acreage of archaeological resources in a reservoir by the number days that those acres
6154 would be exposed – in other words, an “acre-day.” A single “acre-day” is the amount of
6155 exposure created when an archaeological site covering 1 acre is exposed for 1 day. In the same
6156 way, a half-acre site exposed for 2 days would also be 1 acre-day of exposure. Ten acres of
6157 archaeological site exposed for 10 days would be 100 acre-days, and so on. For a single artifact,
6158 a very small collection of related artifacts, or occasionally a single feature, termed an isolate or
6159 isolated find, the states utilize different definitions of isolates and they often represent a single
6160 point on the landscape with no calculated area or acreage. Because of this, isolates were not
6161 used in the analysis. For the tables that follow, the calculations are based on a single water
6162 year.

6163 The data used to support this analysis comes from two sources. First, the information about the
6164 amount of time that particular areas would be exposed come from the reservoir operations
6165 modeling described in Section 3.2 of this EIS. For example, under typical conditions in the No
6166 Action Alternative, Lake Roosevelt is at full pool at 1,290 feet and expected to be below
6167 elevation 1,260 feet. (i.e., the surface of the reservoir is at an elevation of 1,260 feet above
6168 mean sea level) starting by mid-March (about March 15) and ending by late May (about May

6169 20). In other words, areas above elevation 1,260 feet would be exposed at least 67 days every
6170 year under typical conditions. See Section 3.2, *Hydrology and Hydraulics*, for more details.

6171 The second part of this analysis comes from archaeological research in the reservoirs.
6172 Archaeologists have completed an inventory of the archaeological resources in the immediate
6173 vicinity of the reservoirs and in much of the land exposed in the drawdown zone under typical
6174 operating conditions. The boundaries of the archaeological resources have been recorded and
6175 converted into polygons using GIS. The four states covered by this EIS utilize different definitions
6176 of isolates, and often isolates represent a single artifact with no calculated area or acreage.
6177 Therefore, isolates were not included in this analysis. This data, combined with bathymetric
6178 information regarding the elevation of the lands under the reservoirs' surfaces, allows one to
6179 determine which sites are going to be exposed when a reservoir reaches a particular elevation. It
6180 also allows determination of how many acres of archaeological resources are going to be
6181 exposed. For this analysis, the bathymetric information was treated as a series of contours. The
6182 intervals between each contour line usually formed a ribbon that went around the inside of the
6183 reservoir like rings within a bathtub. Each ribbon formed a single elevation interval. At some of
6184 the storage reservoirs, these intervals could be as large as 40 feet, as the storage reservoirs
6185 operate over a large range of elevations. Run-of-river reservoirs, on the other hand, tend to
6186 operate over a range of less than 20 feet. For these reservoirs, the elevation intervals were
6187 usually 1 foot.

6188 Analysis using GIS allowed the determination of how many acres of archaeological resources
6189 were in each elevation interval at each reservoir. This information regarding acreage within
6190 each elevation interval was multiplied by the number of days that each interval would be
6191 exposed to compile acre-day measurements for each of the reservoirs.

6192 The effects analysis also considers other factors, especially the timing of proposed drawdowns
6193 relative to other uses, especially recreation. This will be a qualitative analysis.

6194 The analysis focused on seven of the 14 reservoirs being covered in this EIS. These reservoirs
6195 were included in the analysis because H&H modeling showed that there would be moderate to
6196 major changes (greater than 5% above the No Action Alternative) in reservoir elevation
6197 between different alternatives over the course of a year. The reservoirs included in the analysis
6198 are Albeni Falls, Dworshak, Grand Coulee, Hungry Horse, and Libby (all major storage
6199 reservoirs), John Day (a storage project that is operated like a run-of-river project because it has
6200 limited storage capacity), and Lower Granite (a run-of-river project). For many of the run-of-
6201 river reservoirs, this was not the case—differences between the alternatives were often
6202 negligible or non-existent, especially if one focused on the median (typical) conditions. This was
6203 especially true of Chief Joseph Reservoir (Rufus Woods Lake), which would not undergo any
6204 changes in elevation from the current operations. For the remaining reservoirs on the lower
6205 Columbia River (including McNary), there was negligible to minor difference in operations
6206 between the No Action Alternative and MO1, MO2, and MO3; it is only when one considers
6207 MO4 that operational changes become major in the lower Columbia River Projects. In those
6208 projects or alternatives where it appears that there were no change, negligible, or minor

6209 changes, analysis was limited. See the discussion in Section 3.2 of the modeling effort for more
6210 details on this process, particularly some of the statistical assumptions behind the model.

6211 John Day was included because the modeling showed that there would be minor to major
6212 changes in reservoir elevation between different alternatives. Reservoir elevations would be
6213 higher at certain times of the year under MO1 than under the No Action Alternative, while they
6214 would be lower under MO4. It was important to understand the differences between the
6215 alternatives to analyze the effects of this variability. At Lower Granite, the representative run of
6216 river reservoir, there was little variability between the No Action Alternative and MO1, MO2,
6217 and MO4. Under MO3, though, which includes dam breaching, there is a major change in
6218 reservoir elevations, as the lower Snake River would largely return to pre-reservoir conditions.
6219 Lower Granite was chosen as a representative of the four lower Snake River run-of-river
6220 projects that would be changed because of dam breach because the four dams have similar
6221 configurations and operations. Part of the reason to choose Lower Granite was because of the
6222 availability of some bathymetric data (see below).

6223 The analysis is only as reliable as the information that is available regarding archaeological
6224 resource locations and boundaries. While archaeological inventory is complete for areas along
6225 the immediate reservoir margins, the inventory of all inundated areas is not complete, largely
6226 because archaeological inventory was not completed before the reservoirs were filled in many
6227 cases, and the deeper parts of the reservoirs are exposed only rarely. The GIS data used here is
6228 the best available record of archaeological resource locations available. Examination of the area
6229 of recorded archaeological resources by elevational interval at each of the analyzed reservoirs
6230 shows that a greater area of archaeological sites has been recorded in the upper parts of most
6231 reservoir pools. This pattern does not reflect pre-Contact settlement practices—it reflects the
6232 availability of areas along reservoirs for examination. That is, areas near the upper edge of
6233 fluctuating reservoirs are available for examination more commonly than those near the
6234 bottom, meaning that resources have a greater chance of being observed and recorded.

6235 A related concern is the reliability of the GIS data regarding bathymetric contours. A variety of
6236 sources of bathymetric data were used, some of which are more than 50 years old
6237 (Table 3-290). Only the bathymetric contours from Libby are based on recent side-scan sonar
6238 soundings. The rest are based on topographic data that were gathered before the reservoirs
6239 were filled or during large-scale drawdowns during major construction projects (i.e., Grand
6240 Coulee and Hungry Horse). This means that, in most cases, the available data does not
6241 necessarily reflect changes in the distribution of sediments that were deposited after the
6242 reservoirs were filled.

6243 **Table 3-290. Sources of Bathymetric Data**

Reservoir	Data Type	Citation
John Day	NOAA navigation charts for John Day Reservoir	NOAA (2019a)
Lower Granite	USGS pre-reservoir topographical maps, 7.5-minute series	Almota, Washington (1964; photo revised 1975) Asotin, Washington–Idaho (1971) Clarkston, Washington–Idaho (1971) Colton, Washington (1964; photorevised 1975) Granite Point, Washington (1964; photorevised 1975) Kirby, Washington (1964; photorevised 1975) Silcott, Washington (1971)
Dworshak	Corps bathymetric data	Corps (2019)
Grand Coulee	Reclamation bathymetric data c. 1974	Reclamation (2008)
Albeni Falls	NOAA navigation charts for Lake Pend Oreille; Idaho State bathymetric data	NOAA (2019b); Fields, Woods, and Berenbrock (1996)
Libby	USGS/Corps bathymetric soundings/Reclamation processed c. 2019	Corps (2018)
Hungry Horse	Reclamation bathymetric data c. 1994	Reclamation (2013)

6244 The available bathymetric data for John Day, Lower Granite, and Albeni Falls reservoirs were
 6245 based on relatively large-scale intervals. For example, the bathymetric data from John Day and
 6246 Lower Granite reservoirs were available in either 5- or 10-foot contour intervals. At Albeni Falls,
 6247 the great depth of Lake Pend Oreille means that the available bathymetric contour intervals are
 6248 often 25 feet wide.

6249 The problem comes when the available bathymetric data is compared to the operational ranges
 6250 of these reservoirs. John Day operates over a range of 11 feet, Lower Granite operates over a
 6251 range of 5 feet, and Albeni Falls operations over a range of about 12 feet. In an ideal situation,
 6252 the bathymetric contour data would be available for these reservoirs with narrow operating
 6253 ranges that had 1-foot contour intervals. Unfortunately, such fine-scale data is not available, so
 6254 it became necessary to estimate the acreage of archaeological resources within each 1-foot
 6255 contour interval. This was calculated by determining the acreage of archaeological resources
 6256 within the shallowest bathymetric interval, and then dividing that acreage by the number of
 6257 feet within the interval. For example, at Albeni Falls, it was determined that there were about
 6258 626 acres of archaeological resources within the 12-foot operating range of the reservoir.
 6259 Dividing 626 acres by 12 feet resulted in an estimate of acreage of archaeological resources
 6260 within a single foot of reservoir drawdown zone (52 acres per foot).

6261 Finally, it is also important to note that this analysis of exposure focuses on the median
 6262 conditions as derived from the 5,000-year Monte Carlo simulation developed through the H&H
 6263 analysis of this EIS, discussed further in Appendix B, Hydrology and Hydraulics Data Analysis. As
 6264 seen in the summary elevation hydrographs for each of the alternatives, this data includes the
 6265 daily variation in reservoir elevations, thus capturing some of the seasonal variability in
 6266 operations. It does not show the extremes of operations that might happen if there was a

6267 multi-year drought because the modeling was not continuous from year to year. For the
6268 purposes of comparing the alternatives, the median conditions were determined to be the
6269 most representative of typical conditions over the long term. It also meant that the analysis
6270 would be simplified by only comparing median conditions, rather than by trying to compare dry
6271 year, median year, and wet year conditions between each alternative at each reservoir.

6272 **Erosion**

6273 Increases in bank erosion, and in some cases, mass wasting events, have been observed in
6274 conjunction with rapid draft and refill events, and with depth of drafts at some storage
6275 reservoirs. The influence of each of these factors over erosion rate is dependent on local
6276 topography (slope) and geology (sediment structure). Three measures of draft rate are applied
6277 in this assessment: draft frequency, draft amplitude, and frequency of high draft rate events.

6278 ***Draft Frequency and Amplitude***

6279 For this assessment, draft frequency is the number of reservoir draft and refill sequences within
6280 a specified timeframe. When the reservoir elevation goes above the median elevation of the
6281 reservoir for that particular water year, it is considered one filling event. When the reservoir
6282 goes below the median elevation of the reservoir for that particular water year, it is considered
6283 one drafting event. The total number of refilling and drafting events is the measure of draft
6284 frequency used here. Median reservoir elevation was used for these calculations because
6285 reservoir elevations tend to be skewed toward higher elevations, making median a more
6286 meaningful measure of the central pool elevation tendency than the mean. Any increase in the
6287 number of times pool elevation passed the median as compared with the current condition is
6288 an “adverse” effect, and a reduction in this number is “beneficial.”

6289 Draft amplitude is the difference between minimum and maximum pool elevations as seen
6290 within a single water year. For this assessment, it is assumed (and is consistent with field
6291 observations) that an increase in draft frequency or amplitude increases erosion rates.

6292 ***Frequency of High Draft Rate Events***

6293 Draft rate is another factor influencing the amount of erosion that occurs at some reservoirs in
6294 the Columbia River System. For this assessment, draft rate is measured as the number of feet a
6295 reservoir is drawn down in a specified time frame (i.e., reservoir elevation change from one day
6296 to the next). Each reservoir differs in how it is operated, and each reservoir has different
6297 operational ranges, so it is not possible to say that a draft of 1.5 feet between two days at
6298 McNary is going to have the same effect as a draft of 1.5 feet between two days at Grand
6299 Coulee. McNary is a run-of-river project that operates over a range of about 5 feet, which
6300 means that a change of 1.5 feet between two days is a noticeable change. Grand Coulee, on the
6301 other hand, is a storage reservoir with an elevational range of more than 80 feet. A 1.5-foot
6302 change is a much smaller percentage of the overall depth. There needs to be a way to place
6303 draft rates at each of the reservoirs in its appropriate context.

6304 To calculate what should be considered a High Draft Rate Event at each of the reservoirs for
6305 each of the alternatives, the first step was to calculate the mean daily draft (or fill) rate, which
6306 then enabled one to determine the standard deviation. A High Draft Rate Event was defined as
6307 any daily draft that was more than two standard deviations below the mean. This mean and
6308 standard deviation was readjusted for each individual water year resulting from the Monte
6309 Carlo simulation for each of the reservoirs and alternatives. Individual daily drafts were
6310 compared to this threshold, enabling calculation of a count of high draft rate events within a
6311 single water year. The average number of high draft rate events for each alternative were then
6312 compared to understand the potential for each to increase erosion rates.

6313 **Limitations**

6314 The biggest single limitation of this analysis of the frequency, amplitude, and rate of reservoir
6315 elevation changes is that the methodology is not suitable as a proxy measure of erosion at the
6316 run-of-river projects. Run-of-river reservoirs are not subject to regular seasonal drafting for
6317 water storage. Therefore, water surface elevations do not provide the main measure of
6318 potential effects of alternative river operations on archaeological sites. As seen in the
6319 description of the various operational implications of the alternatives, some of the run-of-river
6320 reservoirs often see a variation of elevation of less than 5 feet over the course of a year. The
6321 key erosion metric for run-of-river reservoirs is flow rate, (flow rate in cfs). Erosion may not
6322 affect as many site acres as storage reservoirs, but erosion effects are more targeted because
6323 the run-of-river projects operate in narrower range, consistently affecting the same area of a
6324 site over time. Volume and timing of flows are the key variables in understanding the effects of
6325 the operational alternatives. See Section 3.2, *Hydrology and Hydraulics*, for more information
6326 about variation in flows between the alternatives.

6327 **TRADITIONAL CULTURAL PROPERTIES**

6328 **Introduction**

6329 The 14 projects that comprise the analysis area for the CRSO EIS also comprise the 14 projects
6330 that have been a part of the FCRPS Cultural Resource Program for the last 20+ years. Over that
6331 time, numerous studies have documented oral histories or traditions and sites or properties of
6332 cultural importance in and around each of the reservoirs. These studies were responsive to a
6333 variety of contract statements of work using different objectives and tasks. This has resulted in
6334 properties defined in different ways due in many cases to the perspective of different tribes
6335 that conducted the studies or different statements of work.

6336 **Analysis**

6337 In conducting this analysis, there are several constraints (e.g., the scale of the analysis and
6338 number of tribes engaged in the EIS) in the data and an assumption made in the methodology.
6339 The assumption is that each property identified by a tribe considered in the analysis is the same
6340 as every other from the standpoint of relative importance. The co-lead agencies were unable to
6341 determine if any of the properties are more or less important from a tribal perspective. For the

6342 purposes of this document they are all considered the same. Not following this assumption
6343 would have entailed extensive consultation with 19 tribes to determine individual tribal
6344 perspectives of importance on TCPs across the CRS. This would have undoubtedly resulted in
6345 differences between the various tribal perspectives that would not have allowed the co-lead
6346 agencies a uniform analysis of effects.

6347 Constraints include the use of only geospatial data for the dataset. This is primarily because of
6348 the nature of other documentation, which, while potentially more useful, is too sensitive to be
6349 shared in a public document. After discussion amongst the co-lead agencies and cooperating
6350 agency tribes, it was decided that because of concerns regarding confidentiality, only geospatial
6351 data would be used.

6352 Another constraint is the data are associated with only the 10 tribes that were participating
6353 actively in the FCRPS Cultural Resource Program at the time of the Notice of Intent to Prepare
6354 the EIS and not the additional 9 tribes consulted during the development of the CRS EIS effort.
6355 However, many of the 10 tribes are in much closer physical proximity to the 14 projects relative
6356 to the other 9 tribes. Nonetheless, physical proximity does not preclude the potential presence
6357 of additional properties associated with the 9 tribes that were not included in this analysis.

6358 An additional constraint is the data used in this analysis was developed over many years by
6359 many different individuals and organizations under contracts with different methodologies and
6360 goals. This is mainly because these contracts were typically to identify properties and assess
6361 effects on a specific site or project rather than on the 14 projects as a whole.

6362 The last constraint is that although the tribes who are cooperating agencies have had a limited
6363 opportunity to review the data, it has been agency staff conducting the effects analysis rather
6364 than contracting the tribes to do it, or working closely with the tribes on an individual basis.

6365 The assumption and these constraints provided the co-lead agencies a balanced methodology to
6366 compare effects across all 14 projects and alternatives. Not allowing for the assumption and
6367 constraints would have resulted in inconsistencies within the analysis between the projects and
6368 alternatives. As previously described, the co-lead agencies utilized a large dataset of over 1300
6369 TCPs to conduct the analysis. The analysis demonstrates the presence of multitudes of TCPs of
6370 different types throughout the 14 projects as well as the past, ongoing, and potential future
6371 effects that would occur as a result of the different alternatives.

6372 **ELEMENTS OF THE BUILT ENVIRONMENT**

6373 Built resources are defined as buildings, structures, or objects that have reached an age of 50
6374 years old and are still in use. Once a built resource is no longer in use and begins to deteriorate,
6375 it becomes an archaeological site, for the purposes of this EIS. Built resources do not need to be
6376 eligible for or listed in the National Register of Historic Places to be considered in this analysis.

6377 Eleven categories of built resources were considered during this analysis. They include
6378 Dams/Locks, Bridges, Railroads, Ferry Terminals, Irrigation Systems, Recreational Facilities,

6379 Residential, Commercial, Port Components, Military Structures, and Religious Structures.
6380 Table 3-288 shows if these resources are present in the study area by project. One assumption
6381 that can be made is that most built resources are not found in the actual reservoirs, with the
6382 exceptions of dams and locks, ferry terminals, foundations of bridges, wharfs and piers that
6383 would be part of port components, portions of irrigation systems, and some recreational
6384 facilities, such as boat ramps. The remaining built resources are out of the reservoir
6385 environment and would not be affected directly by most actions proposed in this EIS, such as
6386 the raising and lowering of water levels in the reservoirs or even the breaching of the lower
6387 Snake River dams in MO3.

6388 **SACRED SITES**

6389 Through the communication process described above, the involved tribes identified two sacred
6390 sites in keeping with the definition provided in Executive Order 13007: Bear Paw Rock, which is
6391 on the shore of Lake Pend Oreille at the Albeni Falls Project; and Kettle Falls, which is inundated
6392 by Lake Roosevelt, the reservoir created by Grand Coulee Dam.

6393 A tribal government employee designated to represent their tribe with respect to cultural
6394 resource issues from the Kalispel Tribe identified Bear Paw Rock as a sacred site. The tribal
6395 representative did not provide a specific, discrete, narrowly delineated boundary for the Bear
6396 Paw Rock sacred site. For the purposes of this study, the boundaries of the existing known
6397 archaeological site will be used as this is entirely on federally owned land. Multiple petroglyphs
6398 are located here and are differentiated from other nearby petroglyph sites in that they are
6399 deeply carved into the rock, with others nearby being lightly pecked into the rock surface. This
6400 site is part of a larger rock art district that is considered eligible for listing in the National
6401 Register of Historic Places. It is a location considered known to the public and a popular
6402 recreation place. The petroglyph panels here likely represent thousands of years of both
6403 continuous tribal activity and continuity in oral traditions related to the importance of the bear
6404 paw motif to tribal belief systems.

6405 Tribal government employees designated to represent their tribes with respect to cultural
6406 resource issues from both the Kalispel Tribe of Indians and the Confederated Tribes of the
6407 Colville Reservation identified Kettle Falls as a sacred site. Neither representative provided a
6408 specific, discrete, narrowly delineated boundary for the Kettle Falls sacred site. For the
6409 purposes of this EIS, the boundaries of this sacred site will be taken as the boundaries of the
6410 Kettle Falls Archaeological District, which was listed in the National Register of Historic Places in
6411 1974. This district includes 19 archaeological sites that were created by Native Americans and
6412 others as they lived at Kettle Falls for more than 10,000 years, and it also includes early historic-
6413 period sites representing the activities of early European American missionaries and merchants
6414 who interacted with the Native Americans who congregated at Kettle Falls for fishing and other
6415 traditional activities. The district encompasses about 2,000 acres, and it is centered on the falls
6416 themselves, which are now permanently inundated. Some of the archaeological resources and
6417 TCPs near the falls become exposed when the reservoir is drawn down, and major features
6418 such as Hayes Island temporarily re-emerge, allowing short-term access. Recent features typical

6419 of the exercise of Native American spirituality have been observed on these landforms when
6420 they re-emerge, indicating the ongoing importance of the area to the Native American
6421 community, which never left the area. Despite these periods of short-term access, the primary
6422 Native American religious activities (especially salmon fishing) are no longer possible in this
6423 location.

6424 **3.16.3.2 Archaeological Resources Effects Across Alternatives**

6425 **ARCHAEOLOGICAL RESOURCES**

6426 **Exposure**

6427 Table 3-291 shows the results from calculating the acre-days of exposure for each of the seven
6428 reservoirs for each of the alternatives within the course of a single year. As one might expect,
6429 the largest reservoir considered here (Grand Coulee), has the greatest amount of acre-days.
6430 This also reflects the fact that Grand Coulee, as storage reservoir, is often used to regulate
6431 flows throughout the rest of the Columbia River System, which means that it has substantial
6432 variability in elevation throughout the year, thus resulting in many days of exposure. Lower
6433 Granite is a unique case, especially when one considers MO3, which would result in the
6434 exposure of all the previously recorded sites. Even though it is a relatively small reservoir, the
6435 breach would result in an increase from about 26,000 acre-days under current conditions to
6436 more than 260,000 acre-days within a single year. John Day, Dworshak, and Albeni Falls form a
6437 second group, where acre-day values range between about 100,000 and 200,000 acre-days.
6438 The final group, which includes Lower Granite, Libby, and Hungry Horse, have acre-day values
6439 between about 15,000 and 50,000 units.

6440 **Table 3-291. Effects to Archaeological Resources – Acre-Day Calculations by Reservoir and**
6441 **Alternative.**

Reservoir	NAA	MO1	MO2	MO3	MO4
John Day	135,000	132,000	135,000	135,000	166,000
Lower Granite	26,000	26,000	26,000	265,000	27,000
Dworshak	112,000	112,000	127,000	111,000	111,000
Grand Coulee	315,000	348,000	355,000	314,000	463,000
Albeni Falls	141,000	141,000	142,000	141,000	152,000
Libby	16,000	16,000	18,000	18,000	16,000
Hungry Horse	38,000	44,000	40,000	45,000	47,000

6442 Note: Values have been rounded to the nearest thousand.

6443 For this analysis, the four MOs are compared to the baseline condition in the No Action
6444 Alternative. This enables us to divide the acre-days exposure for an alternative at a reservoir by
6445 the values from the No Action Alternative, resulting in a percentage. As seen in Table 3-292,
6446 exposure values range from a decrease of 3 percent from the No Action Alternative values
6447 (MO1 for John Day Reservoir) to an increase of 47 percent over the No Action Alternative value
6448 (MO4 for Grand Coulee Reservoir). Variation within ± 5 percent of the No Action Alternative will
6449 be considered negligible to minor, while values with an increase of 6 to 9 percent will be
6450 considered moderate. Exposure values with an increase of 10 percent or greater will be

6451 considered major. MO3 at Lower Granite presents a unique case, as dam breach is expected to
6452 return the lower Snake River to pre-reservoir conditions and expose all the recorded sites. In
6453 this case, there is an increase in exposure of more than 900 percent.

6454 **Table 3-292. Effects to Archaeological Resources – Increases or Decreases in Exposure of**
6455 **Archaeological Resources by Reservoir and Multiple Objective Alternatives**

Reservoir	MO1	MO2	MO3	MO4
John Day	-3% ^{1/}	0% ^{1/}	0% ^{1/}	23% ^{3/}
Lower Granite	0% ^{1/}	0% ^{1/}	915% ^{3/}	4% ^{1/}
Dworshak	0% ^{1/}	13% ^{3/}	-1% ^{1/}	-1% ^{1/}
Grand Coulee	10% ^{3/}	13% ^{3/}	0% ^{1/}	47% ^{3/}
Albeni Falls	0% ^{1/}	0% ^{1/}	0% ^{1/}	7% ^{2/}
Libby	-1% ^{1/}	8% ^{2/}	8% ^{2/}	-2% ^{1/}
Hungry Horse	17% ^{3/}	6% ^{2/}	18% ^{3/}	23% ^{3/}

6456 Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in exposure
6457 (an adverse effect), while a negative value indicates a decrease in exposure (a beneficial effect).

6458 1 Percentage change indicates a ±5% change in the amount of exposure and is considered negligible.

6459 2 Percentage change indicates an increase in amount of exposure between 5% and 10% and is a moderate adverse
6460 effect.

6461 3 Percentage change indicates an increase in the amount of exposure greater than 10% is considered a major
6462 adverse effect.

6463 4 Percentage change indicates a reduction in the amount of exposure greater than 5% and is considered a
6464 beneficial effect.

6465 **Erosion**

6466 ***Draft Frequency and Amplitude***

6467 Table 3-293 provides a summary of the changes in reservoir elevation changes (i.e., draft
6468 frequency). Because this analysis is based on a 5,000-year dataset generated by the Monte Carlo
6469 simulation, it is assumed that any large-scale differences in the frequency of reservoir elevation
6470 changes are statistically important due to the large size of the dataset. The greatest number of
6471 reservoir elevation changes were seen at Grand Coulee for MO1, while the fewest were seen at
6472 Libby for MO1. For both Libby and Albeni Falls, the reservoir elevation either went above the
6473 median or below the median a little over two times a year. This can be seen in the “AVE” column
6474 in the table, which shows the number of times per year that the reservoir level passed above or
6475 below the median elevation. At Hungry Horse, the average was about three times a year, while it
6476 was about four times a year at Dworshak. At Grand Coulee, which showed the most frequent
6477 changes in reservoir elevations, the frequency was closer to six times a year.

6478 **Table 3-293. Effects to Archaeological Resources – Frequency of Reservoir Elevation Changes**
6479 **by Reservoir and Alternative**

Reservoir	Alternative	SUM ^{1/}	AVE ^{2/}	STDEV ^{3/}
Albeni Falls	MO1	12,235	2.45	1.22
Albeni Falls	MO2	12,267	2.54	1.17
Albeni Falls	MO3	12,224	2.44	1.21
Albeni Falls	MO4	12,428	2.49	1.33
Albeni Falls	NAA	12,279	2.46	1.20
Dworshak	MO1	19,319	3.86	1.82
Dworshak	MO2	19,947	3.99	1.62
Dworshak	MO3	19,649	3.93	1.78
Dworshak	MO4	19,667	3.93	1.79
Dworshak	NAA	19,447	3.89	1.73
Grand Coulee	MO1	32,033	6.41	2.62
Grand Coulee	MO2	30,546	6.11	2.65
Grand Coulee	MO3	23,385	4.68	1.30
Grand Coulee	MO4	30,085	6.02	2.09
Grand Coulee	NAA	24,254	4.85	1.44
Hungry Horse	MO1	14,947	2.99	1.41
Hungry Horse	MO2	13,686	2.74	1.25
Hungry Horse	MO3	14,938	2.99	1.40
Hungry Horse	MO4	15,542	3.11	1.34
Hungry Horse	NAA	14,342	2.87	1.24
Libby	MO1	10,247	2.05	0.31
Libby	MO2	10,277	2.06	0.36
Libby	MO3	10,288	2.06	0.38
Libby	MO4	11,217	2.24	0.63
Libby	NAA	10,309	2.06	0.34

6480 1/ SUM = the number of times that the reservoir elevation went above or below the median in the 5,000-year
6481 dataset.

6482 2/ AVE = the average number of times in a single water year that the reservoir went above or below the median.

6483 3/ STDEV = the standard deviation for the average in the adjacent column.

6484 The changes in the total number of elevation changes relative to the median (i.e., SUM in
6485 Table 3-294) can also be compared to the No Action Alternative, resulting in a percentage of
6486 increase or decrease (i.e., Sum of Action Alternative/Sum of No Action Alternative)
6487 (Table 3-294). Values for the No Action Alternative are shown as 0 percent because this was the
6488 baseline for comparison to the other alternatives. The greatest reduction in frequency of
6489 elevation change is seen at Hungry Horse Reservoir under MO2, where there is a 4.6 percent
6490 reduction in the frequency of reservoir elevation changes. The greatest increase is at Grand
6491 Coulee under MO1, where there is a 32.1 percent increase in the frequency of reservoir
6492 elevation changes.

6493 **Table 3-294. Effects to Archaeological Resources – Average Frequency of Reservoir Elevation**
6494 **Change by Alternative**

Project	NAA	MO1	MO2	MO3	MO4
Albeni Falls	0% ^{4/}	0% ^{4/}	0% ^{4/}	0% ^{4/}	1% ^{3/}
Dworshak	0% ^{4/}	-1% ^{5/}	3% ^{3/}	1% ^{3/}	1% ^{3/}
Grand Coulee	0% ^{4/}	32% ^{1/}	26% ^{1/}	-4% ^{5/}	24% ^{1/}
Hungry Horse	0% ^{4/}	4% ^{3/}	-5% ^{6/}	4% ^{3/}	8% ^{2/}
Libby	0% ^{4/}	-1% ^{5/}	0% ^{4/}	0% ^{4/}	9% ^{2/}

6495 Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in the
6496 average frequency of reservoir elevation changes, which is an adverse effect. A negative value indicates a decrease
6497 in the average frequency of reservoir elevation changes, which is a beneficial effect.

6498 1 Increase is greater than 10% relative to the NAA and is considered moderate adverse.

6499 2 Increase is between 5% and 10% and is considered minor adverse.

6500 3 Increase is between 0% and 5% is considered negligible.

6501 4 No difference between the NAA and the alternative.

6502 5 Decrease between 0% and 5% is considered negligible.

6503 6 Decrease between 5% and 10% and is considered minor beneficial.

6504 7 Decrease is greater than 10% relative to the NAA is considered a moderate beneficial.

6505 One can also compare the alternatives based on changes in the amplitude of reservoir elevation
6506 changes, as shown in Table 3-295. As already discussed in the operational overview, the
6507 reservoirs considered here operate over different ranges. Albeni Falls normally operates over a
6508 range of about 12 feet, while other storage reservoirs have much wider elevation ranges. Grand
6509 Coulee operates over a range of about 80 feet, while Dworshak, Hungry Horse, and Libby all
6510 operate over a range of about 160 feet.

6511 **Table 3-295. Effects to Archaeological Resources – Amplitude of Reservoir Elevation Changes**
6512 **by Reservoir and Alternative**

Reservoir	Alternative	Amplitude Mean (feet)	Amplitude Standard Deviation (feet)
Albeni Falls	MO1	11.4	1.1
Albeni Falls	MO2	11.4	1.1
Albeni Falls	MO3	11.4	1.1
Albeni Falls	MO4	10.7	1.6
Albeni Falls	NAA	11.4	1.1
Dworshak	MO1	110.6	32.4
Dworshak	MO2	117.8	30.3
Dworshak	MO3	110.7	32.5
Dworshak	MO4	110.8	32.5
Dworshak	NAA	110.87	32.3
Grand Coulee	MO1	47.4	20.0
Grand Coulee	MO2	46.9	20.4
Grand Coulee	MO3	46.6	19.7
Grand Coulee	MO4	51.3	17.0
Grand Coulee	NAA	46.7	19.4

Reservoir	Alternative	Amplitude Mean (feet)	Amplitude Standard Deviation (feet)
Hungry Horse	MO1	51.9	22.2
Hungry Horse	MO2	53.8	23.1
Hungry Horse	MO3	52.2	21.9
Hungry Horse	MO4	52.0	22.1
Hungry Horse	NAA	49.9	23.4
Libby	MO1	89.9	46.2
Libby	MO2	94.6	41.6
Libby	MO3	94.7	41.6
Libby	MO4	84.0	47.6
Libby	NAA	86.7	49.3

6513 Note: Values have been rounded to the nearest tenth of a foot.

6514 The results of the amplitude analysis follow this same general two-part division between Albeni
6515 Falls and the other reservoirs where amplitudes are greater (Table 3-296). Albeni Falls would
6516 undergo the least change between the MOs as compared to the No Action Alternative.
6517 Effectively, there is no difference between the No Action Alternative and MOs at Albeni Falls.
6518 The differences between the MOs and the No Action Alternative at Libby are all within ± 5
6519 percent of the mean. At Grand Coulee, all the differences between the alternatives in
6520 amplitude are ± 5 percent of the mean except for MO4, where the amplitude would see an
6521 increase of about 9 percent. At Dworshak, the differences between the MOs and the No Action
6522 Alternative are within ± 5 percent of the mean except for MO2, where amplitude would
6523 increase by about 28 percent. Hungry Horse shows the greatest changes in amplitude of all the
6524 reservoirs examined here. All of the MOs would increase amplitude by more than 5 percent.

6525 **Table 3-296. Effects to Archaeological Resources – Changes in Average Amplitude of Reservoir**
6526 **Elevation Change by Alternative**

Reservoir	NAA	MO1	MO2	MO3	MO4
Albeni Falls	0% ^{4/}	0% ^{4/}	0% ^{4/}	0% ^{4/}	0% ^{4/}
Dworshak	0% ^{4/}	0% ^{4/}	28% ^{1/}	0% ^{4/}	0% ^{4/}
Grand Coulee	0% ^{4/}	1% ^{3/}	0% ^{4/}	1% ^{3/}	9% ^{2/}
Hungry Horse	0% ^{4/}	10% ^{2/}	13% ^{1/}	11% ^{1/}	10% ^{2/}
Libby	0% ^{4/}	4% ^{3/}	3% ^{3/}	3% ^{3/}	-1% ^{5/}

6527 Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in the
6528 average amplitude of reservoir elevation changes, which is an adverse effect. A negative value indicates a decrease
6529 in the average amplitude of reservoir elevation changes, which is a beneficial effect.

6530 1 Increase is greater than 10% relative to the NAA and is considered moderate adverse.

6531 2 Increase is between 5% and 10% and is considered minor adverse.

6532 3 Increase is between 0% and 5% is considered negligible.

6533 4 No difference between the NAA and the alternative.

6534 5 Decrease between 0% and 5% is considered negligible.

6535 6 Decrease between 5% and 10% and is considered minor beneficial.

6536 7 Decrease is greater than 10% relative to the NAA is considered a moderate beneficial.

6537 **Draft Rate**

6538 Finally, the results show differences between the alternatives in the number of high draft rate
6539 events (Table 3-297). The greatest number of high draft rate events is seen at Albeni Falls
6540 Reservoir, where the mean number of high draft rate events was about 15 times per year.
6541 Grand Coulee, which has a greater elevation range than Albeni Falls but less than the other
6542 storage reservoirs, usually had about six high draft rate events per year. The other three
6543 reservoirs (Dworshak, Hungry Horse, and Libby) all saw about one or two high draft rate events
6544 per year.

6545 Comparison of the MOs to the No Action Alternative in terms of the average number of high
6546 draft rate events shows a greater level of variability than in the other metrics (Table 3-298). As
6547 with the other metrics, Albeni Falls shows the least amount of difference between the No
6548 Action Alternative and the MOs; all the differences are within ± 5 percent of the No Action
6549 Alternative. At Grand Coulee, all differences are within 10 percent of the No Action Alternative,
6550 with MO3 and MO4 both showing distinct increases. At Dworshak, MO1 shows a dramatic
6551 increase in the average number of High Draft Rate Events, while MO2 shows a marked
6552 decrease. Hungry Horse and Libby also show marked differences between the alternatives. At
6553 both reservoirs, MO2 shows a distinct increase in High Draft Rate Events, and MO3 also has an
6554 increase at Libby. The other alternatives often show a decrease in the High Draft Rate Events.

6555 **Table 3-297. Effects to Archaeological Resources – Rate of Reservoir Elevation Changes by**
6556 **Reservoir and Alternative**

Reservoir	Alternative	Number of High Draft Rate Events Per Year – Mean	Number of High Draft Rate Events Per Year – Standard Deviation
Albeni Falls	MO1	15.7	5.8
Albeni Falls	MO2	15.6	5.9
Albeni Falls	MO3	15.6	5.8
Albeni Falls	MO4	14.9	5.4
Albeni Falls	NAA	15.6	5.9
Dworshak	MO1	4.7	7.9
Dworshak	MO2	1.5	2.6
Dworshak	MO3	2.1	3.6
Dworshak	MO4	2.1	3.6
Dworshak	NAA	2.1	3.6
Grand Coulee	MO1	5.9	6.3
Grand Coulee	MO2	6.0	6.1
Grand Coulee	MO3	6.3	6.6
Grand Coulee	MO4	6.3	6.6
Grand Coulee	NAA	5.8	6.8
Hungry Horse	MO1	0.5	2.0
Hungry Horse	MO2	1.0	3.9
Hungry Horse	MO3	0.5	2.1
Hungry Horse	MO4	0.4	1.9

Reservoir	Alternative	Number of High Draft Rate Events Per Year – Mean	Number of High Draft Rate Events Per Year – Standard Deviation
Hungry Horse	NAA	0.6	2.1
Libby	MO1	0.2	1.3
Libby	MO2	1.3	4.0
Libby	MO3	1.2	3.9
Libby	MO4	0.3	1.5
Libby	NAA	0.7	2.4

6557 **Table 3-298. Effects to Archaeological Resources – Changes in the Average Frequency of High**
6558 **Draft Rate Events by Reservoir and Alternative**

Reservoir	NAA	MO1	MO2	MO3	MO4
Albeni Falls	0% ^{4/}	1% ^{3/}	0% ^{3/}	0% ^{3/}	-4% ^{5/}
Dworshak	0% ^{4/}	126% ^{1/}	-25% ^{5/}	0% ^{3/}	1% ^{3/}
Grand Coulee	0% ^{4/}	1% ^{3/}	3% ^{3/}	7% ^{2/}	8% ^{2/}
Hungry Horse	0% ^{4/}	-19% ^{5/}	71% ^{1/}	-18% ^{5/}	-26% ^{5/}
Libby	0% ^{4/}	-66% ^{5/}	88% ^{1/}	78% ^{1/}	-59% ^{5/}

6559 Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in the
6560 average frequency of high amplitude of reservoir elevation changes, which is an adverse effect. A negative value
6561 indicates a decrease in the average frequency of high amplitude of reservoir elevation changes, which is a
6562 beneficial effect.

6563 1 Increase is greater than 10% relative to the NAA and is considered moderate adverse.

6564 2 Increase is between 5% and 10% and is considered minor adverse.

6565 3 Increase is between 0% and 5% is considered negligible.

6566 4 No difference between the NAA and the alternative.

6567 5 Decrease between 0% and 5% is considered negligible.

6568 6 Decrease between 5% and 10% and is considered minor beneficial.

6569 7 Decrease is greater than 10% relative to the NAA is considered a moderate beneficial.

6570 **3.16.3.3 No Action Alternative**

6571 **ARCHAEOLOGICAL RESOURCES**

6572 Even though the No Action Alternative is considered the baseline by which the MOs are
6573 evaluated, it is important to note that selection of the No Action Alternative would continue to
6574 result in substantial degradation of archaeological resources. This was the conclusion of the
6575 System Operation Review (SOR) FEIS. Continuation of 2016 operations would result in ongoing
6576 loss of archaeological resource integrity. Ongoing degradation of archaeological resources has
6577 been documented in the annual reports produced by the FCRPS Cultural Resource Program.

6578 **Exposure**

6579 See Table 3-291 above for information regarding the number of acre-days that archaeological
6580 resources would be exposed if the No Action Alternative was selected. There are only a few
6581 cases in which the No Action Alternative would result in more adverse effects to archaeological
6582 resources resulting from exposure than one of the MOs. Overall, the No Action Alternative

6583 would tend to result in less adverse effects to archaeological resources resulting from exposure
6584 than the MOs.

6585 **Erosion**

6586 Table 3-297 shows the number of times that reservoir elevations are expected to refill or draft
6587 over the course of the 5,000-year Monte Carlo dataset. The effects resulting from the No Action
6588 Alternative are within ± 5 percent of the effects from the multiple objective alternatives for both
6589 Albeni Falls and Dworshak. In the cases of the No Action Alternative for both Albeni Falls and
6590 Dworshak, the frequency of reservoir elevation changes for all the MOs are all within ± 5
6591 percent of the No Action Alternative (Table 3-298), suggesting that the No Action Alternative
6592 would have effects comparable to these other alternatives. At Grand Coulee, Hungry Horse, and
6593 Libby, the No Action Alternative would result in about the same frequency of reservoir
6594 elevation changes or, in some cases, substantially less changes in reservoir elevation than in
6595 comparison to the MOs.

6596 With regard to changes in amplitude of reservoir elevation changes, the No Action Alternative
6597 shows fewer adverse effects than the MOs in most cases. There are a few cases in which the No
6598 Action Alternative would result in slightly more effects than one of the MOs, but these are
6599 minor. For example, in Table 3-296 the Dworshak row shows that MO1, MO3, and MO4 would
6600 all result in decreases in amplitude that are less than 1 percent. Changes in operations of this
6601 magnitude are considered negligible to minor.

6602 A different pattern is seen in Table 3-298 regarding changes in the number of high draft rate
6603 events per year. For this metric, it appears that some of the MOs could result in slightly less
6604 draft-driven erosion than the No Action Alternative, especially at Hungry Horse and Libby.

6605 Overall, the No Action Alternative would tend to result in less adverse effects to archaeological
6606 resources resulting from erosion than the other alternatives.

6607 **TRADITIONAL CULTURAL PROPERTIES**

6608 Like archaeological resources, there are major effects to TCPs caused by ongoing operations
6609 and maintenance. These effects result from all of the authorized purposes at each respective
6610 project. However, the intensity and breadth of the impact varies from project to project. For
6611 instance, for some projects where navigation is an authorized purpose, there is a relatively
6612 higher frequency of barge traffic subjecting TCPs to a greater amount of effects than reservoirs
6613 where there is a lesser frequency of barge traffic.

6614 Effects as they relate to TCPs can be broken into eight broad categories: inundation, erosion,
6615 public access, visual intrusion, olfactory intrusion, noise intrusion, development, and changes to
6616 the natural environment. These can be grouped into direct, indirect, and cumulative effects.
6617 Assessing which effects are occurring at which properties and to what extent is difficult to
6618 ascertain given the limitations of the available data, as well as the lack of meaningful dialog
6619 with the affected tribal communities to determine effects.

6620 The co-lead agencies assume the ongoing effects of inundation and reservoir fluctuation would
6621 have major effects to properties. Other potential operational effects associated with these

6622 properties can be harder to determine without direct engagement with the affected
6623 community and working through effects on a property-by-property basis. However, as noted on
6624 page 3-1361, *Analysis*, this was not possible because it would have resulted in inconsistencies in
6625 the TCP effects analysis. Effects that are relatively constant throughout a respective reservoir
6626 (barge wakes for instance) would cause effects on any properties located within the fluctuation
6627 zone. Other effects, such as looting, have occurred at specific properties and are likely to occur
6628 in the future at some, but not all properties.

6629 Table 3-299 summarizes effects that have occurred, are occurring, and would continue to occur
6630 as a result of the No Action Alternative. Some of these are direct effects resulting from
6631 operations and maintenance of the projects. Others are indirect effects and result from the
6632 operation and maintenance of the projects but are not directly caused by the operations and
6633 maintenance of the projects. Others are cumulative and would not in themselves constitute a
6634 significant impact, but taken together or in concert with indirect effects, could rise to the level
6635 of a significant impact on specific properties. The Property Specific column in Table 3-299 refers
6636 to effects that cannot be ascribed to specific properties without a good sense of where specific
6637 property types are located. The Reservoir Wide column in Table 3-299 refers to effects that can
6638 be assumed to be occurring to one extent or another across all properties in a given reservoir.

6639 **Table 3-299. Past, Current, and Future Impacts to Traditional Cultural Properties**

Impact	Effect Details	Property Specific	Reservoir Wide	Power Generation	Navigation	Recreation	Fish and Wildlife Conservation
Inundation	Siltation	X		X			
	Sediment shift	X		X	X	X	
	Loss of access		X	X			
	Degradation of cultural deposits/remains	X		X	X		
Erosion	Loss of site landforms	X		X	X	X	X
	Displacement of artifacts/features	X		X	X	X	X
Public Access	Unauthorized activities (litter, camping, boat landings etc.)	X				X	X
	Vandalism	X				X	
	Corps/leased park area (+boat ramp)	X				X	X
	Habitat management units	X					X
	Looting	X				X	
	Trails and unauthorized trails	X				X	X
Visual	Infrastructure (fish hatcheries, parks, levees)	X		X		X	X
	Barge traffic		X		X		
	Recreational boating and water sports		X			X	X
	Fencing and signage	X				X	X
	Access roads	X				X	X
Olfactory	Exhaust from barges		X		X		
	Exhaust from recreational boats/ATV		X			X	X
	Loss of natural smell	X		X			
	Vault toilets	X				X	X
Noise	Loss of natural soundscape	X		X	X	X	X
	Barge noise		X		X		
	Boats/vehicles/equipment	X				X	X

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Impact	Effect Details	Property Specific	Reservoir Wide	Power Generation	Navigation	Recreation	Fish and Wildlife Conservation
Development	Transportation infrastructure (roads)	X				X	X
	Marinas	X				X	X
Changes to Natural Environment	Plant communities	X		X		X	X
	Water quality (turbidity, pollutants, temperature)		X	X	X	X	X
	Fish species		X	X			X
	Air quality	X			X	X	X
	Invasive species	X		X	X	X	X

6640

6641 **Effects of Inundation, Erosion, and Sedimentation**

6642 Although the act of inundation itself is a result of construction, outright inundation of these
6643 resources as a part of operating the projects has an ongoing effect on the tribal communities
6644 that ascribe importance to the properties. This is a result of the reservoir essentially severing
6645 the tribal community's ability to access, view, or otherwise refer to an inundated property,
6646 except through memory. Partial inundation also has similar effects in that it modifies the
6647 appearance of a property relative to its unaltered state. This can include point of reference and
6648 partial obstruction of a property. Ongoing erosion has the physical effect of at least partially
6649 destroying a property located in the fluctuation zone or undercutting a property resulting in
6650 slumping from sediments becoming unstable above the reservoir elevation. Sedimentation can
6651 alter the natural appearance of these properties, alter the ability of communities to access
6652 these properties, and modify the existing local environment such that plant and animal life
6653 traditionally associated with a property are no longer associated.

6654 **ELEMENTS OF THE BUILT ENVIRONMENT**

6655 As part of the No Action Alternative, there would be several structural modifications
6656 constructed at various projects. A few of these modifications will have an effect on the built
6657 resources. At Bonneville Dam, the gatewell orifice would have structural modifications. As
6658 Bonneville Dam is a built resource being more than 50 years old, any modification would be an
6659 effect to a built resource. At both McNary and Ice Harbor Dams, proposed structural measures
6660 include replacing the turbines, which is an adverse effect to a built resource as the structures
6661 are more than 50 years old. The power plant at Hungry Horse Dam began an extensive
6662 modernization effort in fiscal year 2018. This work would bring the facilities to current industry
6663 standards. It would include the full overhaul or replacement of governors, exciters, fixed-wheel
6664 gates, and turbines; a generator rewind; overhaul of the selective withdrawal system; and
6665 recoating the penstocks. In addition, cranes that service the power plant would be refurbished
6666 or replaced, and the powerplant would be brought up to modern fire protection standards. The
6667 replacement of original components of the project would be an effect to built resources by
6668 affecting the historic integrity. All other structural measures to the existing projects would have
6669 no effect to built resources.

6670 In addition to structural measures, there are planned operations that may effect built
6671 resources. At the John Day Project, there is a proposed operational change that would allow for
6672 the rapid evacuation of stored water in emergency and unusual conditions. There is a possibility
6673 this change could effect built resources downriver such as deterioration to port or irrigation
6674 components.

6675 **SACRED SITES**

6676 Implementation of the No Action Alternative would not result in major changes to the Bear Paw
6677 Rock sacred site from the present. Ongoing erosion processes may continue to take place,
6678 though the surrounding landform is dominated by bedrock. A potential effect from recreational
6679 activity may be the ongoing threat of vandalism. The removal of a minimum of at least one

6680 individual image from this site has been documented when comparing early historic
6681 photographs to the modern condition of the site. Also, other defacement episodes of some of
6682 the images has occurred at this location. Any additional vandalism to the site would continue to
6683 result in loss of integrity of the petroglyphs that are the outcome of thousands of years of
6684 Native American history. However, because many of these features rest on bedrock, typical
6685 Lake Pend Oreille operations would not be likely to result in the loss of the landform through
6686 erosional effects. Facilitation of short- or long-term access for Native American religious
6687 practitioners would not be problematic due to the exposed and stabilized location of the site.
6688 Scheduling conflicts with public day use or camping activities at the site may occur.

6689 Implementation of the No Action Alternative would not result in major changes to the Kettle
6690 Falls sacred site from the present. Ongoing erosion processes would continue to take place,
6691 resulting in progressive loss of sediments that cover the various landforms. This would continue
6692 to result in loss of integrity of the archaeological resources that are the outcome of thousands
6693 of years of Native American history. However, because many of these features rest on bedrock,
6694 typical Lake Roosevelt operations would not likely to result in the total loss of the underlying
6695 landforms. During deeper than average drawdowns of Lake Roosevelt, landforms such as Hayes
6696 Island would re-emerge, facilitating short-term access for Native American religious
6697 practitioners.

6698 **SUMMARY OF EFFECTS**

6699 Selection of the No Action Alternative would continue to result in major degradation of
6700 archaeological resources and TCPs due to the direct effects of inundation, erosion, and
6701 sedimentation as well as ongoing indirect effects resulting from continued operations and
6702 maintenance activities. Several structural modifications are planned at the projects as part of
6703 maintenance and capital improvements, some of which may have an effect on the built
6704 resources. Implementation of the No Action Alternative would not result in major changes to
6705 the Bear Paw Rock or Kettle Falls sacred sites.

6706 See Section 3.16.3.2 for a summary of effects to archaeological resources across all alternatives.

6707 **3.16.3.4 Multiple Objective Alternative 1**

6708 **ARCHAEOLOGICAL RESOURCES**

6709 **Exposure**

6710 See Table 3-291 above for information regarding the number of acre-days that archaeological
6711 resources would be exposed if MO1 was selected. The effects of MO1 in comparison to the
6712 baseline established by the No Action Alternative are presented in Table 3-292. In short,
6713 implementation of MO1 is expected result in major effects, by increasing the exposure of
6714 archaeological resources at Grand Coulee Dam (Lake Roosevelt) by 10 percent, and at Hungry
6715 Horse Reservoir by 17 percent. The other reservoirs show negligible changes in exposure as
6716 measured by acre-days. Based on the summary elevation hydrographs showing that reservoir

6717 elevations under MO1 do not differ from the No Action Alternative for the run-of-river projects
6718 that were not analyzed using this technique (i.e., Bonneville, The Dalles, McNary, Ice Harbor,
6719 Lower Monumental, Little Goose, Lower Granite, and Chief Joseph), no or negligible effects are
6720 expected due to changes in exposure.

6721 **Erosion**

6722 Table 3-293 above shows the frequency of reservoir elevation changes for MO1, and the
6723 frequency of these changes is compared to the No Action Alternative in Table 3-294. At the five
6724 storage reservoirs, MO1 would result in minor effects by altering the frequency of reservoir
6725 elevation changes by less than ±5 percent, except for Grand Coulee, where MO1 would result in
6726 a major effect of about a 32 percent increase. In terms of amplitude, Table 3-295 compares
6727 MO1 to the No Action Alternative. All the changes would be minor except for Hungry Horse,
6728 where the amplitude of elevation changes would increase by about 10 percent and would
6729 therefore be moderate to major. Considering the number of high draft rate events for MO1,
6730 Dworshak would see a major effect with an increase of greater than 100 percent in comparison
6731 to No Action Alternative. At Hungry Horse and Libby, on the other hand, there would be a
6732 marked decrease in the number of High Draft Rate Events, suggesting that some of the
6733 mechanisms of erosion would be restrained.

6734 **TRADITIONAL CULTURAL PROPERTIES**

6735 Under MO1, TCPs would be subject to effects ranging from no change to major, as shown in
6736 Table 3-300. However, based on available data and the effects of the MO1 measures, there
6737 does not appear to be a change in effects relative to the No Action Alternative at most projects.
6738 This is because, operationally, there is not enough difference between the No Action
6739 Alternative and MO1 to identify a greater or lesser relative effect as a result of reservoir
6740 fluctuations due to operational measures. The exception is Grand Coulee, which is expected to
6741 increase in frequency of elevation changes as shown in the archaeological analysis and would
6742 likely lead to a greater rate of erosion of properties and therefore a major effect. Dworshak
6743 would experience a major effect with a large increase in the number of high draft events which
6744 could moderately affect TCPs. However, this is effect uncertain because the high drafts could
6745 lead to increased access and visibility of TCPs, which could be beneficial depending on the views
6746 of the affected tribal community. The storage reservoirs would be drafted lower and therefore
6747 would potentially increase erosion at TCPs. Table 3-300 shows the overall characterization of
6748 effects to TCPs by reservoir. No change means TCPs would be expected to incur the same
6749 effects under MO1 as they currently do under the No Action Alternative.

6750 **Table 3-300. Effects to Traditional Cultural Properties by Alternative**

Dam	MO1	MO2	MO3	MO4
Bonneville	No change	No change	No change	Minor effect
The Dalles	No change	No change	No change	Minor effect
John Day	No change	Minor effect	Moderate effect	Minor effect
McNary	No change	No change	No change	Minor effect

Dam	MO1	MO2	MO3	MO4
Ice Harbor	No change	Minor effect	Moderate effect ^{1/}	Minor effect
Lower Monumental	No change	Minor effect	Moderate effect ^{1/}	Minor effect
Little Goose	No change	Minor effect	Moderate effect ^{1/}	Minor effect
Lower Granite	No change	Minor effect	Moderate effect ^{1/}	Minor effect
Dworshak	Major effect	Moderate effect	No change	No change
Chief Joseph	No change	No change	No change	No change
Grand Coulee	Major effect	Moderate effect	No change	Major effect
Albeni Falls	No change	No change	No change	No change
Libby	NA	NA	NA	NA
Hungry Horse	Minor effect	Minor effect	No change	Major effect

6751 Note: NA = not applicable. The co-lead agencies had no geospatial TCP data for Libby.

6752 1/ Moderate effects to TCPs at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite are expected
6753 immediately following dam breach, but are expected to shift to beneficial effects in the period after due to
6754 increased access to these properties by tribal communities.

6755 **ELEMENTS OF THE BUILT ENVIRONMENT**

6756 MO1 has several structural measures proposed. Most of the structural measures would not
6757 affect built resources because the structures are not 50 years old or because the action is
6758 reversible, which means the resource can be restored to a pre-modification state. Table 3-301
6759 shows the structural measures and the magnitude of effect for built resources. At Bonneville
6760 Dam, the proposed measure to modify the upper ladder serpentine flow control ladder would
6761 affect the fish ladder in a non-reversible manner. At McNary and Ice Harbor, there is a proposed
6762 measure to construct additional powerhouse surface passage routes. New construction at the
6763 powerhouses, both of which are more than 50 years old, would only affect built resources if the
6764 powerhouse itself needs to be modified in some manner to support the new construction. If the
6765 new construction does not modify the powerhouses, there would be no effect to built resources.
6766 Upgrading spillway weirs to Adjustable Spillway Weirs (ASWs) at John Day, McNary, and Lower
6767 Monumental would affect the resources that are more than 50 years old by modifying historic
6768 materials and design. MO1 has no structural measures at Dworshak, Chief Joseph, Grand Coulee,
6769 Albeni Falls, Libby, or Hungry Horse.

6770 **Table 3-301. Structural Measures Planned Under Multiple Objective Alternative 1 Having an**
6771 **Effect on Built Resources**

Project	Project Components Being Modified	Effect to Built Resources
Bonneville	Modify upper fish ladder serpentine flow control ladder sections at Bonneville Dam	This structural measure would have minor effects on built resources as the action is not reversible and the Oregon side of the project is over 50 years old, with construction being completed in 1937.
Lower Monumental	Upgrade spillway weir to Adjustable Spillway Weir (ASW)	Proposed structural measure would have a minor effect on built resources as the project is over 50 years old (construction completed in 1969).

6772 There are multiple operational measures proposed under MO1 that could have an adverse
6773 effect to historic resources. There would be elevational changes such as deeper drawdowns, at

6774 reservoirs such as Grand Coulee, that could affect built resources, such as ferry terminals,
6775 recreational facilities, and irrigation. With water levels being at lower levels in some reservoirs,
6776 the resources could be unusable. To make them usable, portions of the resources may need to
6777 be modified, which would affect the historic value of the built resources. Additionally, the
6778 increase and decrease of water level at Grand Coulee could be more or less rapid. Where more
6779 rapid, it could cause landslides and erosion, which could cause minor to moderate effects to
6780 built resources. Anticipated effects to infrastructure, specifically transportation, resources are
6781 discussed in greater detail in section 3.10. Similar to the No Action Alternative, this change
6782 could effect built resources, such as ferry terminals, recreational facilities, and irrigation. With
6783 water being at lower levels, these resources could be unusable in their current condition. To
6784 make them usable, portions of the resources may need to be modified, which may affect the
6785 historic value of the built resources. The earlier drawdown at Grand Coulee seen in the winter
6786 months could affect built resources including ferry terminals and recreational facilities. By
6787 drawing down deeper, some of these resources may need to be modified for continued
6788 operation.

6789 **SACRED SITES**

6790 Under MO1, the frequency of deeper drawdowns is not expected to increase at Albeni Falls.
6791 Thus, the anticipated effect to Bear Paw Rock under this alternative would remain the same as
6792 discussed above in the No Action Alternative.

6793 Under MO1, the frequency of deeper drawdowns at Kettle Falls is expected to increase, and
6794 this means that some of the archaeological resources and TCPs associated with this sacred site
6795 would be exposed for a greater period. This exposure is likely to result in an increase in looting
6796 of materials from the surface of the site, and this looting is often seen as a degradation of the
6797 sacredness of the site. At the same time, the increased period of exposure would provide for a
6798 somewhat greater level of access to places such as Hayes Island. This may facilitate an increase
6799 in Native American religious use of this landform.

6800 **SUMMARY OF EFFECTS**

6801 Implementation of MO1 is expected to result in major effects, by increasing the exposure of
6802 archaeological resources at Grand Coulee Dam (Lake Roosevelt) and at Hungry Horse Reservoir.
6803 The other reservoirs show negligible changes in exposure. Grand Coulee would increase in
6804 frequency of elevation changes and would likely lead to a greater rate of erosion of TCPs. An
6805 increase in the number of high draft events at Dworshak could lead to a moderate effect on
6806 TCPs, although these effects could also be beneficial with increased access and visibility.
6807 Structural measures at McNary and Ice Harbor may have an effect to built resources, as may
6808 modification of spillway weirs at John Day, McNary, and Lower Monumental. Operational
6809 measures at reservoirs such as Grand Coulee could affect built resources, either by making
6810 these built resources unusable for a greater amount of time or by increasing erosion. The
6811 frequency of deeper drawdowns at Kettle Falls would result in some of the archaeological
6812 resources and TCPs being exposed for a greater period, leading to increased access and use, but
6813 also a potential increase in looting.

6814 **3.16.3.5 Multiple Objective Alternative 2**

6815 **ARCHAEOLOGICAL RESOURCES**

6816 **Exposure**

6817 See Table 3-291 above for information regarding the number of acre-days that archaeological
6818 resources would be exposed if MO2 was selected.

6819 The effects of MO2 in comparison to the baseline established by the No Action Alternative are
6820 presented in Table 3-292. MO2 would result in major effects at Dworshak and Grand Coulee,
6821 which would undergo a 13 percent increase in the exposure of archaeological resources. MO2
6822 would result in moderate effects at Libby and Hungry Horse, which would see an increase in
6823 archaeological resource exposure of 8 percent and 6 percent, respectively. The other reservoirs
6824 addressed here (John Day, Lower Granite, and Albeni Falls) would not undergo changes in
6825 archaeological resource exposure. Based on the similarity between the summary elevation
6826 hydrographs for the No Action Alternative and MO2 for most of the run-of-river projects
6827 (Bonneville, The Dalles, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite,
6828 and Chief Joseph), no differences in exposure are expected at these projects from MO2 as
6829 compared with the No Action Alternative.

6830 **Erosion**

6831 Table 3-293 above shows the frequency of reservoir elevation changes for MO2, and the
6832 frequency of these changes is compared to the No Action Alternative in Table 3-294. At the five
6833 storage reservoirs, MO2 would have minor effects, altering the frequency of reservoir elevation
6834 changes by less than ± 5 percent, except for Grand Coulee, where MO2 would result in a major
6835 effect and an increase of about 26 percent. Major effects to amplitude would be seen at Hungry
6836 Horse and Dworshak, where amplitude would increase by 13 percent and 28 percent
6837 respectively. Both Hungry Horse and Libby would see major effects with increases in the
6838 number of high draft rate events each year.

6839 **TRADITIONAL CULTURAL PROPERTIES**

6840 Under MO2, TCPs would also be subject to direct effects from all authorized purposes at each
6841 project, as shown in Table 3-300. Under MO2, there could be increased effects over time at
6842 lower Snake River reservoirs because of the proposed operational measure to operate the LSR
6843 projects within the full reservoir operating range year round. This measure would allow for
6844 more flexibility in operations, which could lead to more frequent shifts in reservoir elevation
6845 and thus increased erosion. Properties in Lower Granite, Little Goose, Lower Monumental, and
6846 Ice Harbor reservoirs could be subject to effects as a result of implementing this measure, but
6847 this does not seem to be borne out by the hydrographs. Similar effects could occur to TCPs in
6848 the John Day reservoir by allowing the project to operate within the full reservoir operating
6849 range year-round. However, as noted in the archaeological resources effects above, there does
6850 not appear to be a change in the hydrographs reflecting a substantial effect from the John Day

6851 full pool operational measure. Similarly, by drafting the storage projects slightly deeper for
6852 hydropower, effects could occur where TCPs are present in the drawdown zone (Grand Coulee,
6853 Hungry Horse, Dworshak) by allowing for wider and more frequent range of shifts in reservoir
6854 elevations.

6855 **ELEMENTS OF THE BUILT ENVIRONMENT**

6856 The structural measures in MO2 that would affect built resources would be very similar to
6857 those described in MO1 (Table 3-302). At McNary and Ice Harbor, fish surface passage routes to
6858 the powerhouses would be added. This action alone would not affect the powerhouses, which
6859 are both older than 50 years old, unless there is a need to modify the existing structures. If the
6860 existing structures need to be altered in any way, it would affect the historic characteristics to
6861 the powerhouses. The proposed measure to upgrade the existing spillway weirs to adjustable
6862 spillway weirs at McNary, Ice Harbor, and Lower Monumental projects would result in effects.
6863 As these spillways are part of the original construction of the projects, they are more than 50
6864 years old and any modification would affect their historical character. No other proposed
6865 structural measures in MO2 would affect built resources.

6866 **Table 3-302. Structural Measures Planned Under Multiple Objective Alternative 2 and Their**
6867 **Effect on Built Resources**

Project	Structural Measure	Effect to Built Resources
John Day	Construct JDA/MCN/IHR powerhouse surface passage routes; also, Upgrade spillway weirs to ASWs	New construction would not affect built resources unless powerhouse would need to be modified during the construction. The powerhouse is over 50 years old and modifications to it could be a minor effect to built resources
McNary	Construct JDA/MCN/IHR powerhouse surface passage routes; also, Upgrade spillway weirs to ASWs	New construction would not affect built resources unless powerhouse would need to be modified during the construction. The powerhouse is over 50 years old, built in 1954, and modifications to it could be a minor effect to built resources.
Ice Harbor	Construct JDA/MCN/IHR powerhouse surface passage routes	New construction would not affect built resources, unless powerhouse would need to be modified during the construction. The powerhouse is over 50 years old, built in 1961, and modifications to it could be a minor effect to built resources.
	Upgrade spillway weirs to ASWs	Proposed modifications would have a negligible effect to built resources. The project construction was completed in 1961.
Lower Monumental	Upgrade spillway weirs to ASWs	Proposed modifications would have a negligible effect on built resources. The project construction was completed in 1969.

6868 MO2 proposes a number of operational measures that could have an effect on built resources.
6869 The operational measures proposed in MO2 are similar to MO1 in that they would create
6870 elevational changes at pools. Anticipated effects to infrastructure, specifically transportation,
6871 resources are discussed in greater detail in section 3.10. To allow for greater operational
6872 flexibility for hydropower generation, there could also be deeper drawdowns, which could
6873 result in built resources, such as ferry terminals, recreational facilities, and irrigation, being
6874 impacted or altered to make them usable. Ferry terminals at Grand Coulee are a main source of
6875 transportation across the reservoir. If there are deeper drawdowns for extended periods of

6876 time, it may result in the need to modify the terminals to make them usable to lower
6877 elevations. At the Grand Coulee Project, MO2 proposes to have low reservoir levels for
6878 extended periods of time. When the pool is at low winter reservoir levels, ferry terminals and
6879 recreational facilities, such as boat ramps, are unusable. If there are extended drawdowns, it
6880 may be determined that these resources would need to be altered to be usable, especially the
6881 ferry terminals, as they are a main source of transportation across the pool. To provide the
6882 space needed, the reservoirs would need to be drafted more deeply from mid-December to
6883 March. Similar to other operational measures that would create deeper drawdowns, this
6884 measure could have a minor effect on built resources, such as ferry terminals, recreational
6885 facilities, irrigation, roads, and bridges.

6886 **SACRED SITES**

6887 Under MO2, the frequency of deeper drawdowns is not expected to increase at Albeni Falls.
6888 Thus, the anticipated effect to Bear Paw Rock under this alternative would remain the same as
6889 discussed above in the No Action Alternative.

6890 Under MO2, the level of effects to Kettle Falls would be similar to that seen under MO1. The
6891 frequency of deeper drawdowns is expected to increase under MO2, but not to the same
6892 extent as MO1. This means that some of the archaeological resources and TCPs associated with
6893 this sacred site would be exposed for a greater period. This exposure is likely to result in an
6894 increase in looting of materials from the surface of the site, and this looting is often seen as a
6895 degradation of the sacredness of the site. At the same time, the increased period of exposure
6896 would provide for a somewhat greater level of access to places such as Hayes Island. This may
6897 facilitate an increase in Native American religious use of this landform.

6898 **SUMMARY OF EFFECTS**

6899 MO2 would result in major effects in exposure at Dworshak and Grand Coulee, and moderate
6900 effects at Libby and Hungry Horse. MO2 would result in a major effect at Grand Coulee in terms
6901 of the frequency of reservoir elevation changes, along with major effects to amplitude at
6902 Hungry Horse and Dworshak. Structural measures at McNary and Ice Harbor may have an effect
6903 to built resources, as would modification of spillway weirs at John Day, McNary, and Lower
6904 Monumental. Operational measures at reservoirs such as Grand Coulee could affect built
6905 resources, either by making these built resources unusable or by increasing erosion. The
6906 frequency of deeper drawdowns at Kettle Falls would result in some of the archaeological
6907 resources and TCPs being exposed for a greater period, leading to increased access and use, but
6908 also a potential increase in looting.

6909 **3.16.3.6 Multiple Objective Alternative 3**

6910 **ARCHAEOLOGICAL RESOURCES**

6911 **Exposure**

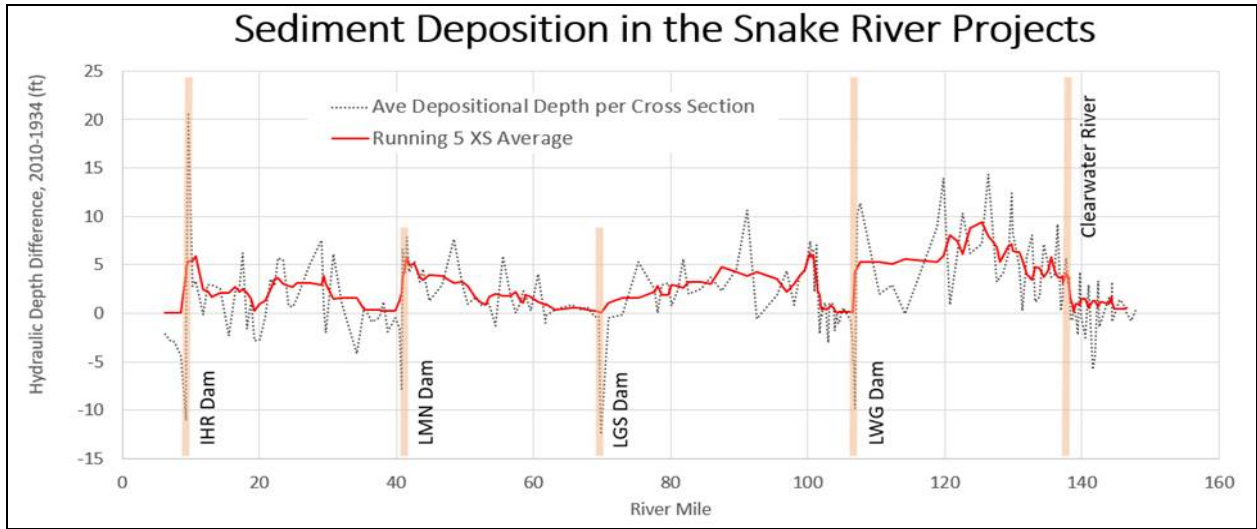
6912 See Table 3-291 above for information regarding the number of acre-days that archaeological
6913 resources would be exposed if MO3 was selected.

6914 The effects of MO3 in comparison to the baseline established by the No Action Alternative are
6915 presented in Table 3-292. Because MO3 would involve breaching the lower Snake River dams, it
6916 would have major effects on archaeological resources in comparison to the other alternatives.
6917 Therefore, this discussion of exposure will focus on the other dams and reservoirs first, and
6918 then cover Lower Granite, which is being included here as representative of the effects on the
6919 lower Snake River.

6920 Four of the seven reservoirs analyzed here (John Day, Dworshak, Grand Coulee, and Albeni
6921 Falls) would undergo negligible changes in archaeological resource exposure. Libby would see a
6922 moderate (8 percent) increase in the exposure of archaeological resources, while Hungry Horse
6923 would see a major (18 percent) increase.

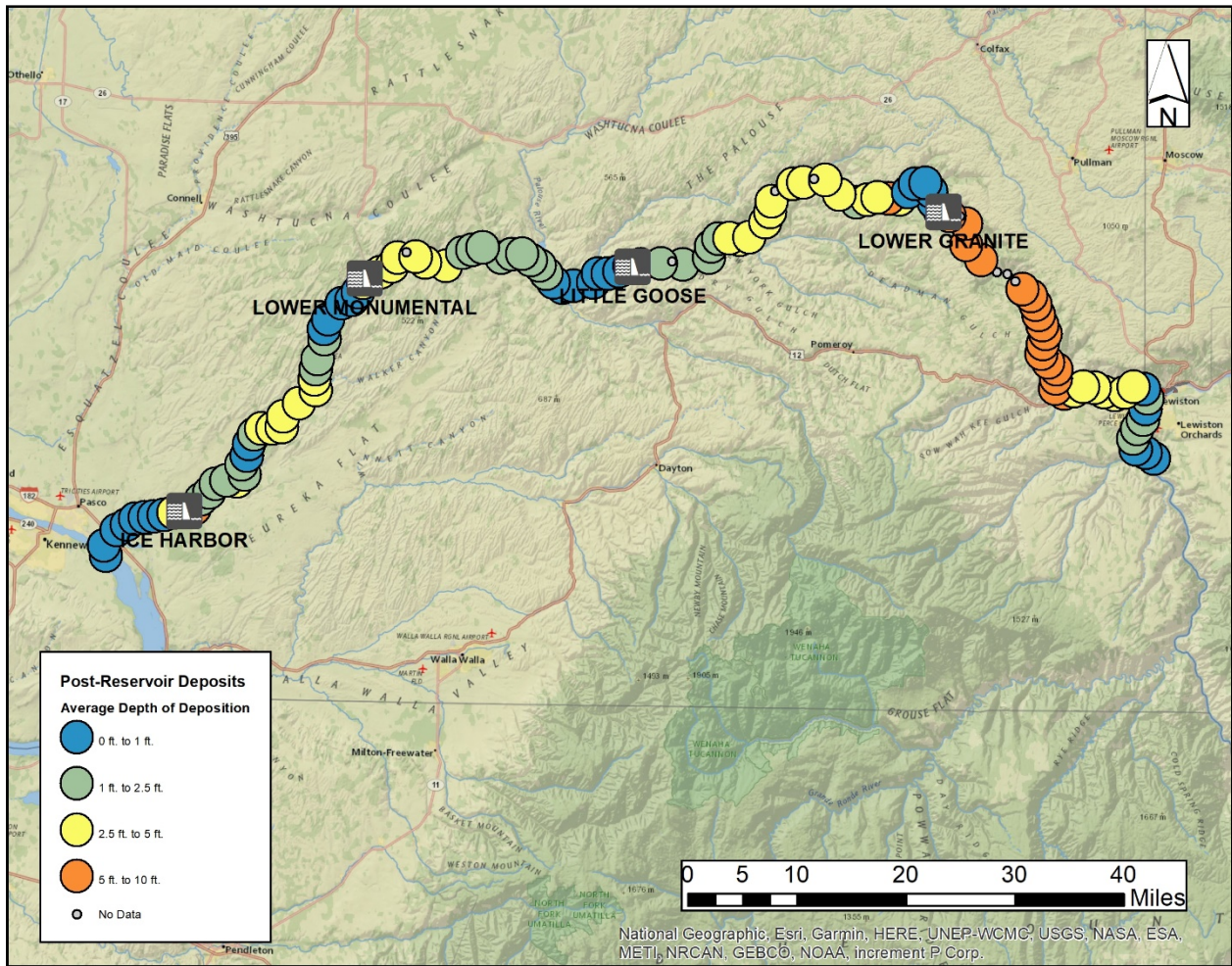
6924 MO3 would result in a major effect in exposure of archaeological resources at Lower Granite.
6925 Under the No Action Alternative, the exposure of archaeological resources is about 26,000 acre-
6926 days per year. Under MO3, with the reservoir being drawn down to the level of the original
6927 river, it is assumed here that all archaeological resources identified during the pre-reservoir
6928 archaeological investigations would be exposed, resulting in an increase to 265,000 acre-days of
6929 archaeological resource exposure. This represents a major (915 percent) increase. If the four
6930 lower Snake River reservoirs are considered as a group, breaching the dams would result in the
6931 exposure of a total of 293 archaeological sites with an aggregate area of about 2,125 acres, at
6932 minimum. Recent experience at other reservoirs with deep drafts suggests that many more
6933 sites are likely to be present (see discussion below). However, analysis in Section 3.3, *River*
6934 *Mechanics* of post-reservoir deposition shows that sediments cover some areas along the lower
6935 Snake River up to a depth of about 10 feet. (Figure 3-225; Figure 3-226). It is important to note
6936 that not every location within the existing reservoir would be covered with the thickness of
6937 sediment shown in Figure 3-226. Some areas would experience erosion as shown by the
6938 negative values in Figure 3-225.

6939 As discussed in Section 3.3, *River Mechanics*, the general pattern behind Ice Harbor Dam and
6940 Lower Monumental Dam is for post-reservoir sediments to be thickest just upstream from the
6941 dams, with accumulations trailing off farther upstream. The pools behind Little Goose and
6942 Lower Granite show a pattern of sediment accumulation with greatest deposition in the upper
6943 half of the reservoirs. Accumulations along the lower Snake River are greatest in the Lower
6944 Granite pool, which is the most upriver of the lower Snake River dams and ends up acting as the
6945 settling basin for much of the rest of the system. Accumulations are lowest just downstream of
6946 the four dams.



6947
 6948

Figure 3-225. Sediment Deposition in the Snake River Projects



6949
 6950

Figure 3-226. Map of Average Sediment Depth by River Mile in the Snake River Projects

6951 These patterns of sediment distribution have direct implications for the analysis of MO3 effects
6952 to archaeological resources. In some stretches of the lower Snake River, post-reservoir
6953 sediments may cap archaeological resources. This is especially true in the stretch of the lower
6954 Snake River from the mouth of Alpowa Creek at about River Mile 131 to Lower Granite Dam at
6955 about River Mile 107. This “reservoir cap” would have the benefit of obscuring archaeological
6956 resources that would otherwise be vulnerable to increased rates of damage by their exposure.
6957 The greater thickness of sediments over archaeological sites within Lower Granite Reservoir in
6958 comparison to Little Goose was field verified during the 1992 test drawdown (Andrefsky 1992).
6959 At the same time, these post-reservoir sediments would not be as consolidated as the pre-
6960 reservoir sediments that make up the bed and banks. Researchers working along the lower
6961 Snake River during the 1992 test drawdown noted sloughing happening as the river system
6962 adjusted to the new conditions (Andrefsky 1992; Dauble and Geist 1992). Slumping, especially
6963 of the poorly consolidated post-reservoir sediments, is especially likely given the reduction of
6964 reservoir elevation at a rate of 2 feet per day, which is the rate proposed for this alternative.

6965 **Erosion**

6966 Table 3-293 above shows the frequency of reservoir elevation changes for MO3, and the
6967 frequency of these changes is compared to the No Action Alternative in Table 3-294. At the five
6968 storage reservoirs, MO3 would result in minor effects by altering the frequency of reservoir
6969 elevation changes by less than ± 5 percent at all the reservoirs. This MO has the least change
6970 from the No Action Alternative of all the MOs regarding frequency of reservoir elevation
6971 changes. In terms of amplitude of reservoir elevation changes, only Hungry Horse shows a
6972 moderate increase in amplitude greater than 5 percent. When it comes to the number of high
6973 draft rate events, MO3 shows moderate to major effects with increases greater than 5 percent
6974 at Grand Coulee (7.4 percent increase) and Libby (78.4 percent increase) only.

6975 **Other Effects of Multiple Objective Alternative 3**

6976 MO3 is distinctive in the set of alternatives considered here because it includes the breaching
6977 of the four lower Snake River dams. Because of this, it is necessary to consider other effects
6978 that are unique to this alternative.

6979 One of the consequences of MO3 would be the exposure of approximately 14,000 acres that
6980 were formerly inundated (Corps 2002). Over the long term, some of this area is likely to be
6981 recolonized by plants, but in other places (especially those lacking nearby perennial sources of
6982 water), recolonization would be slow or incomplete. The delay or incompleteness in
6983 recolonization would have effects on archaeological resources arising through several
6984 mechanisms, which have been observed by site monitors at Lake Roosevelt and other Projects.
6985 First, those areas where plant colonization happens slowly or not at all will be prone to gully
6986 erosion, especially during late summer thunderstorms when large amounts of rain may be
6987 dumped on the ground in a short period of time, or during rain-on-snow events during the late
6988 winter and early spring (Figure 3-227). The sheet flow of water across the denuded surface of
6989 the drawdown zone could result in dramatic erosion. By removing the soil, artifacts would be

6990 shifted in position, making it harder for archaeologists to understand the associations between
6991 artifacts and activities.



6992
6993 **Figure 3-227. Gully Erosion in an Exposed Drawdown Zone, Lake Roosevelt, 2017**

6994 Second, the lack of ground cover would also lead to increased indirect effects to sites resulting
6995 from human activity, and recent experience with a non-Federal project in another part of
6996 Eastern Washington provides a guide on what may occur. In 2014, the reservoir behind
6997 Wanapum Dam had to be drawn down to relieve stress during repair of the dam (Lenz 2016).
6998 The drawdown resulted in the exposure of areas that had been inundated since the 1960s, and
6999 the public responded with great interest. People started driving vehicles on the exposed
7000 reservoir bed. Some pedestrians walking on the newly exposed sediments even became stuck
7001 in the exposed post-reservoir sediments because they had an almost quicksand like quality.
7002 Extraction required the help of law enforcement personnel (Robinson 2014). Because of
7003 concerns about both public safety and the integrity of exposed archaeological resources, Grant
7004 County Public Utility District #2 worked with property owners to close the reservoir to public
7005 access during the entire length of the emergency drawdown (DeLeon 2014).

7006 These lessons can be applied to the breaching of the lower Snake River dams. Archaeological
7007 sites located in places where vegetation cover is not quickly reestablished would be much more
7008 visible than under typical reservoir operating conditions. The presence of archaeological sites
7009 along the lower Snake River is well known to the public (Judd 2017), and exposed sites would
7010 be much more likely to be subject to both organized looting and casual collecting of surface
7011 artifacts. There is also a high likelihood that vehicles would be driven over the exposed
7012 reservoir bed, resulting in degrading of archaeological resource integrity.

7013 Experience from the Wanapum Dam emergency response points to other factors that also need
7014 to be considered when managing archaeological resources. Exposed pre- and post-reservoir
7015 sediments exposed during the drawdown quickly dried out, resulting in the formation of deep

7016 polygonal cracks (Figure 3-228). Because of their size and extent, these cracks allowed recent
7017 materials to penetrate deeper into the sediments, resulting in mixing of materials between
7018 strata. This kind of mixing degrades the integrity of archaeological resources.



7019
7020 **Figure 3-228. Polygonal Crack Formation, Wanapum Drawdown, 2014**
7021 Source: DeLeon (2014)

7022 Finally, another factor to consider is that we may not fully understand the effects of the
7023 drawdown because we do not know the location of all the archaeological resources in the lower
7024 Snake River dam pools. During the response to the Wanapum Dam drawdown, the public utility
7025 district arranged to have a large archaeological crew conduct an emergency archaeological
7026 survey of the exposed area. They relocated 59 previously recorded sites and found 50 new
7027 archaeological resources. Lenz (2016) concluded that this recording of a greater number of
7028 archaeological resources than were previously known likely resulted from increased
7029 thoroughness of archaeological field methods since the 1960s and the much greater ground
7030 surface visibility available during a post-reservoir survey when vegetation is not present. Given
7031 that the lower Snake River projects were inventoried for archaeological resources at about the
7032 same time and using generally the same field methodologies as the contemporaneous
7033 Wanapum Pool, it is anticipated that the number of archaeological resources recorded in the
7034 lower Snake River pools may increase by about 85 percent after the drawdown. This means that
7035 the current count of 293 sites may increase by 249 sites to a total of 542 sites. Overall, MO3 is
7036 expected to result in major short-term and long-term effects associated with the breaching of
7037 the lower Snake River dams.

7038 Dam breaching could result in increased access to archaeological resources for scientific
7039 investigations using conventional terrestrial archaeological techniques. This is a negligible
7040 beneficial effect, especially in the context of the adverse major effects resulting from exposure.

7041 **TRADITIONAL CULTURAL PROPERTIES**

7042 Under MO3, TCPs would be subject to effects ranging from no change to moderate as shown in
7043 Table 3-269. However, these effects would not be the same at Ice Harbor, Lower Monumental,
7044 Little Goose, or Lower Granite projects where moderate effects would occur in the event of
7045 dam breaching. Following dam breaching, some properties would experience moderate effects
7046 similar to archaeological sites associated with sediment erosion and deposition. Properties
7047 could also experience increased indirect effects under MO3 associated with public access
7048 including looting, vandalism, creation of trails, and unauthorized activities. These effects could
7049 be moderate during the period immediately following the drawdown of each reservoir,
7050 particularly in areas in close proximity to access points along the reservoirs or near population
7051 centers. During the 1992 test drawdown, some projects experienced an increased public
7052 presence simply due to the public having access to areas that had been inundated for more
7053 than 20 years.

7054 Following the drawdown, the goal would be for the river to return to as natural a condition as
7055 possible. In the long term, this would be expected to have a beneficial effect to TCPs. Many of
7056 these properties consist of areas that were used for fishing, gathering, occupation, or legendary
7057 sites. Restoration of a natural river would allow tribal communities that attach importance to
7058 these areas to access them and, in the long-term, experience the river as it was prior to
7059 inundation. Overall, MO3 is expected to result in moderate effects to TCPs affected by the
7060 lower Snake River dam breaching.

7061 Moderate effects are also expected to occur at John Day as a result of the John Day full pool
7062 operational measure. Overall, MO3 is expected to result in moderate effects to TCPs affected
7063 by the lower Snake River dam breaching.

7064 **ELEMENTS OF THE BUILT ENVIRONMENT**

7065 MO3 has several structural measures that would affect built resources (see Table 3-303), but
7066 the largest effect to built resources would be the breaching of lower Snake River dams, which
7067 involves breaching the earthen embankments, abutments, and adjacent structures of the Ice
7068 Harbor, Lower Monumental, Little Goose, and Lower Granite projects would affect the built
7069 environment. Lower Granite, built in 1975, has not reached 50 years in age, and as such, the
7070 breaching of the dam would not have an effect to built resources at that project. However, Ice
7071 Harbor, built in 1961; Lower Monumental, built in 1969; and Little Goose, built in 1970, are all
7072 more than 50 years old, and the breaching of the embankment, abutments, and adjacent
7073 structures would be a major effect to built resources and would reduce the historic value of the
7074 projects. Anticipated effects to infrastructure resources, specifically transportation, are
7075 discussed in greater detail in section 3.10.

7076 **Table 3-303. Structural Measures Planned Under Multiple Objective Alternative 3 and Their**
7077 **Effect on Built Resources**

Project	Project Components Being Modified	Effect to Built Resources
McNary	Construct additional powerhouse surface passage routes	New construction would not affect built resources, unless the powerhouse needs to be modified during the construction. The powerhouse is over 50 years old, built in 1954, and modifications to it could be a minor effect to built resources.
Ice Harbor	Remove earthen embankments, abutments, and adjacent structures	Proposed dam breach would have a major effect on built resources. The project construction was completed in 1961.
	Modify turbines for use as low-level water outlets to support controlled drawdown of the reservoirs	Modification of turbines would have a negligible effect on a built resource.
Lower Monumental	Remove earthen embankments, abutments, and adjacent structures	Proposed dam breach would have a major effect on built resources,
	Modify turbines for use as low-level water outlets to support controlled drawdown of the reservoirs	Modification of turbines would have a negligible effect on built resources.
Little Goose	Remove earthen embankments, abutments, and adjacent structures	Proposed dam breach would have a major effect on built resources,
	Modify turbines for use as low-level water outlets to support controlled drawdown of the reservoirs	Modification of turbines would have a negligible effect on built resources.
Lower Granite	Remove earthen embankments, abutments, and adjacent structures	Proposed dam breach would have a major effect on built resources,
	Modify turbines for use as low-level water outlets to support controlled drawdown of the reservoirs	Modification of turbines would have a negligible effect on built resources.

7078 In addition to breaching the dams, there are other structural measures that would amend built
7079 resources and reduce the historic value of the projects. Constructing additional powerhouse
7080 surface passage routes alone would not affect the powerhouses, which are both greater than
7081 50 years old, unless there is a need to modify the existing structures. If the existing structures
7082 need to be altered in any way, it would affect the historic characteristics to the powerhouses.
7083 As these spillways are part of the original construction of the projects, they are more than 50
7084 years old and any modification would affect their historical character. Modifying turbines at Ice
7085 Harbor, Lower Monumental, Little Goose, and Lower Granite for use as low-level water outlets
7086 to support controlled drawdown of the reservoirs would be an effect to built resources because
7087 the turbines are original parts of the projects. An alteration to an original component would
7088 diminish the historic value of the structures. MO3 has no structural measures at Dworshak,
7089 Chief Joseph, Grand Coulee, Albeni Falls, Libby, or Hungry Horse.

7090 Several operational measures that are part of MO3 could create effects to built resources.
7091 Modification of equipment for a controlled reservoir evacuation during the dam breach would
7092 alter original components of the dams and would ultimately diminish the historic value of Ice
7093 Harbor, Lower Monumental, and Little Goose. As with MO1 and MO2, MO3 would have
7094 operational changes that create elevational changes in the levels of water at pools. Such
7095 changes include lower drawdowns and increases or decreases of water levels that could be
7096 more or less rapid. Similar to the other MOs, these changes could result in built resources being
7097 affected. Of special concern are ferry terminals and recreational facilities. If any of these
7098 resources need to be altered to be usable during lower water levels, it could affect the historic
7099 nature of the resources and create a minor effect. Overall, MO3 would have a major effect on
7100 the built resources associated with the lower Snake River projects.

7101 As a part of MO3, the agencies would alter the maximum daily draw down rate from 1.5 ft/day
7102 to 0.8 ft./day. This change in the drawdown rate means that drawdown has to start earlier in
7103 the year than it does currently, resulting in increased periods of exposure at certain elevations.
7104 When the pool is at low winter reservoir levels, ferry terminals and recreational facilities, such
7105 as boat ramps, are unusable, and MO3 would expand this somewhat. If there are extended
7106 drawdowns, it may be determined that these resources would need to be altered to be usable,
7107 especially the ferry terminals because they are a main source of transportation across the pool.
7108 If this happens, it could change built resources and make them lose historic value. At Hungry
7109 Horse, the reservoir could be 4 to 6 feet lower by the end of summer as compared to the No
7110 Action Alternative. This may have an effect on built resources, especially recreational facilities.
7111 Summer months are the busiest time at the reservoir and when the recreational facilities are
7112 used the most. To accommodate a lower reservoir, the facilities may need to be modified to be
7113 used, which could change the original components of the built resource.

7114 **SACRED SITES**

7115 Under MO3, the frequency of deeper drawdowns is not expected to increase at Albeni Falls.
7116 Thus, the anticipated effect to Bear Paw Rock under this alternative would be the same as
7117 discussed above in the No Action Alternative.

7118 MO3 is expected to have similar effects to the Kettle Falls sacred site as described under the No
7119 Action Alternative. The changes in operations proposed for Lake Roosevelt under this MO are
7120 negligible (at least in terms of elevation), so there should not be a change in effects.

7121 **SUMMARY OF EFFECTS**

7122 Because MO3 would involve breaching the lower Snake River dams, it would have a major
7123 effect on archaeological resources in comparison to the other alternatives. In some stretches of
7124 the Snake River, post-reservoir sediments may cap archaeological resources and would have
7125 major effects. At Lower Granite, archaeological resources would be exposed 915 percent more
7126 than under the No Action Alternative. One of the consequences of MO3 would be the exposure
7127 of approximately 14,000 acres that were formerly inundated, which would affect archaeological
7128 resources through increased erosion, cracking, and increased effects due to human activity.

7129 TCPs initially would be subject to moderate effects under MO3 at the breached lower Snake
7130 River projects associated with sediment erosion and deposition, along with increased looting,
7131 vandalism, creation of trails, and unauthorized activities. At the same time, the exposure of the
7132 TCPs would allow resumption of some traditional uses that have not been possible since the
7133 dams were built, and this is viewed as a beneficial effect. Removal of the embankment,
7134 abutments, and adjacent structures of the lower Snake River projects would be major effects to
7135 these built resources and would reduce their historic value.

7136 **3.16.3.7 Multiple Objective Alternative 4**

7137 **ARCHAEOLOGICAL RESOURCES**

7138 **Exposure**

7139 See Table 3-291 above for information regarding the number of acre-days that archaeological
7140 resources would be exposed if MO4 was selected.

7141 The effects of MO4 in comparison to the baseline established by the No Action Alternative are
7142 presented in Table 3-292. Three of the five storage reservoirs show increases in the exposure of
7143 archaeological resources in denuded drawdown zones: Albeni Falls, Grand Coulee, and Hungry
7144 Horse. Major effects would occur due to increases in exposure at Grand Coulee and Hungry
7145 Horse, with exposures increasing by 47 percent and 23 percent respectively. For this
7146 alternative, operations would also include lowering the level of John Day Reservoir and the
7147 other lower Columbia River projects to help with faster particle travel time for fish migration.
7148 This would also have the major effect of increasing exposure of archaeological resources by 23
7149 percent in comparison to the No Action Alternative baseline. Finally, Albeni Falls (Lake Pend
7150 Oreille) would undergo a moderate increase of exposure of archaeological resources of about 7
7151 percent. While not as marked as the greatly increased exposures at Grand Coulee, Hungry
7152 Horse, and John Day, it is consistent with the overall pattern of substantial increases in pressure
7153 on archaeological resources that would be likely to result from implementation of this
7154 alternative.

7155 It is important to highlight the effects that would be created by the *Drawdown to MOP*
7156 measure, which is an aspect of MO4. The measure would cause the run-of-river projects on the
7157 lower Snake and lower Columbia Rivers to be drawn down to MOP during the spring and
7158 summer months to reduce fish travel times. The effects of this measure are moderate in that
7159 there is a 23 percent increase in acre-day exposure at John Day Reservoir, and it is anticipated
7160 that similar effects would take place at the other run-of-river reservoirs, especially along the
7161 lower Columbia River. While the *Drawdown to MOP* measure pertains to both the lower Snake
7162 and lower Columbia River Projects, the results of the modeling indicate that it would not result
7163 in an actual change in operations in the lower Snake River Projects. Summary elevation
7164 hydrographs show that the reservoir elevations in the lower Snake River Projects are actually
7165 0.25 foot higher under MO4 than under No Action Alternative during the spring and summer
7166 months. However, actual operations would leave these reservoir elevations potentially similar
7167 to the NAA. At the lower Columbia River reservoirs, the *Drawdown to MOP* measure results in a

7168 lowering of the pool by about 2 to 3 feet, depending on the reservoir. With John Day as a guide,
7169 this indicates that the exposure of archaeological sites is likely to experience moderate effects,
7170 with an increase in the range of 25 percent in the other run-of-river projects on the lower
7171 Columbia River, as well.

7172 **Erosion**

7173 Table 3-293 above shows the frequency of reservoir elevation changes for MO4, and the
7174 frequency of these changes is compared to the No Action Alternative in Table 3-294. At all five
7175 storage reservoirs, MO4 would result in minor to major effects to archaeological resources
7176 through increased frequency of reservoir elevation changes. The situation would be only
7177 slightly more adverse at Albeni Falls and Dworshak, but the effects at the other reservoirs
7178 would be much more marked. At Grand Coulee, the increase in the frequency of reservoir
7179 elevation changes would be about 24 percent.

7180 A somewhat different picture emerges when one looks at the changes in amplitude that would
7181 accompany implementation of MO4 (Table 3-295). Again, MO4 would result in moderate
7182 effects at both Grand Coulee and Hungry Horse reservoirs due to increases in amplitude.
7183 Changes at the other three storage reservoirs would be negligible. Regarding the number of
7184 high draft rate events within a single year, again there would be an increase at Grand Coulee,
7185 where such events would increase from an average of 5.8 times per year under the No Action
7186 Alternative to 6.3 times per year under MO4 (Table 3-296). This represents a moderate effect
7187 and an increase of about 8.1 percent. At the other storage reservoirs, the changes in the
7188 number of high draft rate events is either negligible (Albeni Falls and Dworshak) or potentially
7189 beneficial (Hungry Horse). At Hungry Horse and Libby, implementation of MO4 is likely to
7190 reduce the number of high draft rate events within a single year by as much as 59 percent.

7191 MO4 is the alternative that shows the most major adverse effects relative to the No Action
7192 Alternative. Although most of the run-of-river reservoirs were not included in the exposure
7193 analysis due to a lack of bathymetric data, examination of the summary elevation hydrographs
7194 for the lower Columbia River and the lower Snake River projects shows that all of them would
7195 undergo lower reservoir levels in comparison with the No Action Alternative during the spring
7196 and summer months under MO4. That would also result in increased exposure of
7197 archaeological resources during a period when public use of these rivers is increased. This is
7198 expected to result in increased damage to the archaeological resources.

7199 **TRADITIONAL CULTURAL PROPERTIES**

7200 Under MO4, TCPs would be subject to effects, as shown in Table 3-300. However, based on the
7201 available data and operational measures in MO4, increased effects relative to the No Action
7202 Alternative would only occur at the Grand Coulee and Hungry Horse Projects. This is based on
7203 the frequency of elevation changes at these reservoirs as described in the archaeological site
7204 effect analysis. Other minor effects relative to the No Action Alternative are expected to occur
7205 at the run-of-river reservoirs as a result of increased exposure.

7206 **ELEMENTS OF THE BUILT ENVIRONMENT**

7207 Several of the structural measures associated with MO4 would be similar to structural
7208 measures seen in other alternatives. Table 3-304 shows an evaluation of all the structural
7209 measures that are proposed as part of MO4 and their effect to historic resources.
7210 Implementation of the proposed measure to construct additional powerhouse surface passage
7211 routes alone would not affect the powerhouses, which are both older than 50 years old, unless
7212 there is a need to modify the existing structures. If the existing structures need to be altered in
7213 any way, it would affect the historic characteristics to the powerhouses. The addition of a
7214 spillway weir notch gate insert at the McNary, Ice Harbor, Lower Monumental, and Little Goose
7215 projects would modify the original spillways, which would alter the historic value of the
7216 projects. No other structural measures in MO4 would affect historic resources. Anticipated
7217 effects to infrastructure resources, such as ferry terminals, are discussed in greater detail in
7218 section 3.10.

7219 **Table 3-304. Structural Measures Planned Under Multiple Objective Alternative 4 and Their**
7220 **Effect on Built Resources**

Project	Project Components Being Modified	Effect to Built Resources
McNary	Construct additional powerhouse surface passage routes	New construction would not affect built resources unless powerhouse needs to be modified during the construction. The powerhouse is over 50 years old, built in 1954, and modifications to it could be a minor effect to built resources.
	Addition of spillway weir notch gate insert	Modification of the spillway would have a negligible effect to built resources.
Ice Harbor	Construct additional powerhouse surface passage routes	New construction would not affect built resources unless powerhouse needs to be modified during the construction. The powerhouse is over 50 years old, built in 1961, and modifications to it could be a minor effect to built resources.
	Addition of spillway weir notch date insert	Modification of the spillway would have a negligible effect to built resources.
	Addition of spillway weir notch gate insert	Modification of the spillway would have a negligible effect to built resources.

7221 There are a few operational measures under MO4 that would affect built resources. When the
7222 pool is at low winter reservoir levels, ferry terminals and recreational facilities, such as boat
7223 ramps, may be unusable. If there are extended drawdowns, it may be determined that these
7224 resources would need to be altered to be usable, especially the ferry terminals, as they are a
7225 main source of transportation across the reservoir. These actions may alter the historic
7226 resources. Lower summertime reservoir levels at Albeni Falls, along with deeper drafts at Libby
7227 and Hungry Horse during the spring could affect built resources, especially recreational
7228 facilities, and irrigation features. Spring reservoir levels at Hungry Horse could be up to 15 feet
7229 lower than the No Action Alternative if one dry year is followed by another dry year, which
7230 could have an effect on built resources, especially recreational facilities.

7231 **SACRED SITES**

7232 Under MO4, effects to Bear Paw Rock would be greater than that seen under the No Action
7233 Alternative, MO1, MO2, and MO3. In dryer-than-normal years, the summer reservoir elevation
7234 for Albeni Falls Dam would be lower than for the No Action Alternative and other MO
7235 Alternatives. Given the bedrock nature of the landform, this MO would not likely have an
7236 increased erosional effect. Access to the location may be affected if water levels are lower. This
7237 may result in not only less public access, which may be a benefit, but also less tribal visitation to
7238 the site.

7239 Under MO4, effects to Kettle Falls would be greater than that seen under MO1 and MO2 to
7240 Kettle Falls. The increase in resource exposure is expected to increase markedly under MO4 at
7241 Lake Roosevelt. This means that some of the archaeological resources and TCPs associated with
7242 this sacred site would be exposed for a greater period. This exposure would be likely to result in
7243 an increase in looting of materials from the surface of the site. At the same time, the increased
7244 period of exposure would provide for a somewhat greater level of access to places such as
7245 Hayes Island. This may facilitate an increase in Native American religious use of this landform.

7246 **SUMMARY OF EFFECTS**

7247 Implementation of MO4 is expected to result in major effects by increasing the exposure of
7248 archaeological resources at Grand Coulee Dam (Lake Roosevelt), and Hungry Horse Reservoir.
7249 MO4 would have moderate effects on John Day and the other lower Columbia River projects
7250 associated with the implementation of the *Drawdown to MOP* measure during spring and
7251 summer months to reduce fish travel times measure. MO4 would result in the highest erosion
7252 of any of the alternatives as the lower reservoir levels would result in increased exposure of
7253 archaeological resources. TCPs would be subject to major effects at Grand Coulee and Hungry
7254 Horse. The addition of a spillway weir notch gate insert at the McNary, Ice Harbor, Lower
7255 Monumental, and Little Goose projects would modify the original spillways, which would alter
7256 the historic value of the projects. Bear Paw Rock and would be subject to greater exposure and
7257 effects associated with modification in access. Kettle Falls would be subject to greater exposure
7258 and effects associated with erosion and modifications in access.

7259 **3.17 INDIAN TRUST ASSETS, TRIBAL PERSPECTIVES, AND TRIBAL INTERESTS**

7260 The area potentially affected by the CRSO EIS alternatives has served as a homeland since time
7261 immemorial for multiple Indian tribes. The rivers and the resources they have historically
7262 supported are critical elements of many tribes' sense of place and identity. As a result, any
7263 evaluation of CRS operations should consider how changes to river conditions affect tribal
7264 interests. This section accordingly considers those effects, which have also been considered
7265 throughout this analysis for resources of particular importance to tribes.

7266 The following section discusses the affected environment and environmental consequences for
7267 Indian Trust Assets, tribal perspectives, and tribal interests. As discussed below, Indian Trust
7268 Assets are a particular type of tribal interest that were analyzed. Certain tribes provided their
7269 holistic perspectives on how the CRS affects tribal interests. The co-lead agencies have attached
7270 those perspectives in their entirety as appendices, and provided summaries and key excerpts
7271 here. Finally, this section evaluates effects to tribal treaty resource interests.

7272 **3.17.1 Indian Trust Assets**

7273 **3.17.1.1 Introduction and Background**

7274 The Department of the Interior (DOI) requires that all effects to Indian Trust Assets (ITAs), even
7275 those considered nonsignificant, be discussed in NEPA analyses and appropriate compensation
7276 and/or mitigation implemented. ITAs are legal interests in property held in trust by the United
7277 States for Indian tribes or individuals. ITAs include trust lands, natural resources, trust funds, or
7278 other assets held by the Federal government in trust. An Indian trust asset has three
7279 components: (1) the trustee, (2) the beneficiary, and (3) the trust asset.

7280 Treaty-reserved rights, for instance, fishing, hunting, and gathering rights on and off
7281 reservation, are usufructuary rights that do not meet the Department of Interior (DOI)
7282 definition of an ITA. A usufruct is the legal right to use and derive profit or benefit from
7283 property that belongs to another person. The United States does not own or otherwise hold
7284 these resources in trust. ITAs do not normally include usufructuary rights alone (i.e., rights to
7285 access for hunting or fishing). Rather, they require first a possessory interest; that is, the asset
7286 must be held or owned by the Federal government as trustee.

7287 Reclamation's NEPA Handbook (2012) recommends a separate ITA section in all NEPA
7288 documents including a ROD. These sections should be prepared in consultation with potentially
7289 affected tribal trust beneficiaries.

7290 **3.17.1.2 Affected Environment**

7291 The area of analysis is defined as the 14 dam and reservoir locations (hydroelectric projects)
7292 and an area extending 1 mile in all directions from the reservoir full pool elevation to include
7293 the tailrace of each dam.

7294 The co-leads consulted with the following 19 Federally recognized tribes to determine the
7295 presence of and effects on ITAs:

- 7296 • Burns Paiute Tribe
- 7297 • Coeur d'Alene Tribe of Indians
- 7298 • Confederated Salish and Kootenai Tribes of the Flathead Reservation
- 7299 • Confederated Tribes of the Chehalis Reservation
- 7300 • Confederated Tribes of Grand Ronde Community of Oregon
- 7301 • Confederated Tribes of Siletz Indians of Oregon
- 7302 • Confederated Tribes of the Colville Reservation
- 7303 • Confederated Tribes of the Umatilla Indian Reservation
- 7304 • Confederated Tribes of Warm Springs Reservation of Oregon
- 7305 • Confederated Tribes and Bands of the Yakama Nation
- 7306 • Cowlitz Indian Tribe
- 7307 • Fort McDermitt Paiute and Shoshone Tribes of the Fort McDermitt Indian Reservation
- 7308 • Kalispel Tribe of Indians
- 7309 • Kootenai Tribe of Idaho
- 7310 • Nez Perce Tribe
- 7311 • Shoalwater Bay Indian Tribe
- 7312 • Shoshone-Bannock Tribes of the Fort Hall Reservation
- 7313 • Shoshone-Paiute Tribes of Duck Valley Reservation
- 7314 • Spokane Tribe of Indians

7315 Coordination of consultation and information sharing with the tribes was conducted through
7316 the Tribal Liaison Team (TLT), which is composed of representatives from all three of the co-
7317 lead agencies. A Federal point-of-contact (POC) for each of the 19 tribes was established and
7318 serves as the primary conduit for coordination of consultation and information sharing.
7319 Conversely, each tribe has identified a POC for similar purposes.

7320 The process for identifying ITAs and evaluating effects from the alternatives includes:

- 7321 • Initial outreach letter to tribes requesting information.
- 7322 • Query Reclamation's geospatial database.
- 7323 • Coordinate with the Bureau of Indian Affairs on identified trust lands.
- 7324 • Prepare affected environment and environmental consequences sections of the draft EIS.
- 7325 • Share these sections with tribes who provided input.
- 7326 • Finalize draft EIS sections.

7327 **GEOSPATIAL DATABASE QUERY**

7328 Reclamation queried its geospatial database that identifies “Native American lands,” meaning
7329 reservation and trust land, within the study area. Trust land within the study area includes lands
7330 from the following tribes:

- 7331 • Confederated Tribes of Warm Springs Reservation
- 7332 • Yakama Nation
- 7333 • Kootenai Tribe of Idaho

7334 The database also includes Indian reservations within the study area. They include:

- 7335 • Confederated Tribes of the Colville Indian Reservation
- 7336 • Spokane Tribe of Indians
- 7337 • Kalispel Tribe of Indians
- 7338 • Kootenai Tribe of Idaho
- 7339 • Nez Perce Tribe
- 7340 • Confederated Salish and Kootenai Tribes of the Flathead Reservation

7341 Reclamation coordinated with the BIA Northwest Regional Office in Portland, Oregon. Those
7342 trust lands confirmed by BIA are considered in this ITA analysis.

7343 **TRIBAL OUTREACH**

7344 On July 6, 2018, the co-leads sent a letter to each of the 19 tribes requesting information
7345 regarding ITAs. The following section details the information received during the outreach
7346 effort and subsequent follow-up with both tribal and Federal POCs. Information was received
7347 from the Confederated Tribes of the Colville Reservation, the Nez Perce Tribe, and the Kootenai
7348 Tribe of Idaho.

7349 **Confederated Tribes of the Colville Reservation**

7350 A letter was received from the CTCR on September 6, 2018. This letter states that the co-lead
7351 agencies “present too narrow a view of the concept [of ITAs].” Further, the CTCR offered their
7352 interpretation derived from their reading of the various regulations that discuss ITAs:

7353 Emphasizing land and water rights ignores other property-based legal interests. The
7354 CTCR’s trust assets extend to natural resources such as use of waterways and the fish
7355 and wildlife subject to the Tribes’ federally protected rights in the Columbia, Okanogan
7356 and North Half.

7357 Additionally, the CTCR discussed cultural resources as ITAs:

7358 Reclamation’s guidance is clear. In the Bureau of Reclamation Indian Trust Asset Policy
7359 and NEPA Implementing Procedures, on page 3, item 1-6 discusses “When is a Cultural

7360 Resource an ITA?” The answer is that cultural resources are ITAs, depending on where
7361 they are found. Item IV-6, on page 9, describes “How should Reclamation consider
7362 effects to cultural resources that may be ITAs?” The answer provided is to follow their
7363 responsibilities under NEPA, the Archaeological Resources Protection Act, and the
7364 National Historic Preservation Act. Item IV-8, on page 10, asks “Should social and
7365 cultural values be considered when addressing impacts on ITAs?” The answer is - “Yes.”

7366 The United States does not hold a possessory interest in trust for the benefit of the CTCR or its
7367 members for the “use of waterways and the fish and wildlife subject to the Tribes’ federally
7368 protected rights.” The rights of the CTCR to use waterways, hunt, fish, and gather resources are
7369 usufructuary rights lacking the trust asset necessary to give rise to an ITA. Nevertheless, given
7370 the importance of these resources to the CTCR and other tribes, effects to those resources are
7371 discussed in Section 3.17.3, *Tribal Interests*.

7372 For a cultural resource, that is, those resources subject to historic preservation laws, to be
7373 considered an ITA often depends on the ownership status of the particular cultural resource
7374 and the land on which the resource is found. Cultural resources located on trust land are often
7375 the property of the tribe or Indian beneficiary, but could also be held by the United States in
7376 trust as part of the real property estate. Cultural resources located on public lands are owned
7377 by the Federal government, held for the benefit of the public at large, and are generally not
7378 considered ITAs (Bureau Reclamation Indian Trust Asset Policy and NEPA Implementing
7379 Procedures, 1994). Cultural resources meeting this definition have been identified. As a result,
7380 effects to all cultural resources are discussed in Section 3.16, *Cultural Resources*.

7381 **Nez Perce Tribe**

7382 An email was received from the Nez Perce Tribe on December 4, 2018, and states:

- 7383 • Indian trust lands (both tribal trust and individual allotment) located within one mile of the
7384 main Clearwater River and its three main forks (North, Middle, and South), on the Nez Perce
7385 Reservation...
- 7386 • The Clearwater River bed and banks—that land from ordinary high water mark to ordinary
7387 high water mark across the river on the main Clearwater and all three main navigable forks
7388 (North, Middle, South)—is tribal trust land and an ITA. (See attached PDF, 2016 DOI M-
7389 Opinion (M-37033) confirming trust status). Among other things, Dworshak Dam is located
7390 on trust-held riverbed, and trust-held riverbed remains located as well under the portion of
7391 the Dworshak Reservoir lying within the 1863 Nez Perce Reservation . . .
- 7392 • Nez Perce Tribe multi-use/treaty-based water rights within the Nez Perce Reservation are
7393 ITAs. (See attached PDF, NPT-SRBA 2007 Consent Decree, listing all of those water rights,
7394 from both surface and groundwater sources, within the Reservation.) It is probably
7395 acceptable to just consider the smaller subset of those treaty-based water rights for which
7396 the water source is the main Clearwater River and its three main forks. Those particular
7397 water rights will be found in the initial sections of the attached Consent Decree PDF . . .
- 7398 • Nez Perce treaty rights reserved in its 1855 Treaty with the United States, and the natural
7399 resources subject to those reserved rights, are ITAs, and in this instance include at least Nez

7400 Perce fishing, hunting, and gathering rights, on and off reservation, within the EIS action
7401 area; and the fisheries, wildlife, and plant life resources that are subject to those treaty-
7402 reserved rights within the EIS action area.

7403 The Department of the Interior does not agree with the Nez Perce Tribe's assertion that treaty
7404 hunting, fishing, and gathering rights are ITAs and are subsequently not discussed in this
7405 section. However, effects to resources related to treaty rights are discussed in other areas of
7406 Chapter 3. Title to the lands encompassing the Clearwater River bed and banks are not
7407 identified in the BIA records as trust lands. Those lands are, therefore, not considered as ITAs in
7408 this analysis.

7409 Additionally, the Department of Interior recognizes the Nez Perce Tribe's water rights in the
7410 Clearwater River. However, effects to those rights are not anticipated since none of the
7411 proposed alternatives identify changes in the existing operation of Dworshak Dam.

7412 **Kootenai Tribe of Idaho**

7413 The KTOI requested a map of trust land identified during the geospatial database query. The co-
7414 leads responded via email on August 30, 2018, with a map identifying those lands. KTOI
7415 responded on September 5, 2018, with a map that includes "all of the lands held in trust by the
7416 United States for the benefit of the Kootenai Tribe or individual Indians and some fee land
7417 (Mirror Lake) the Tribe intends to place into trust."

7418 The BIA identified those lands currently held in trust for the Kootenai Tribe. Those lands are
7419 considered in this analysis; lands not yet held in trust are not considered in this ITA analysis.

7420 **3.17.1.3 Environmental Consequences**

7421 No direct or indirect effects to ITAs relative to the no-action alternative were identified for any
7422 of the alternatives. Trust lands identified during the geospatial database query and tribal
7423 outreach are located outside of any direct or indirect effects identified in the alternatives.
7424 These include lands from the Confederated Tribes of Warm Springs Reservation, the Yakama
7425 Nation, and the KTOI, as well as the six Indian reservations identified above.

7426 **3.17.2 Tribal Perspectives Summaries**

7427 **3.17.2.1 Introduction and Background**

7428 The purpose of this section is to provide federally recognized tribes potentially affected by the
7429 operations and maintenance of the Columbia River System (CRS) the opportunity to present, in
7430 their own words, their perspective of the operations and maintenance of the CRS, and the
7431 effects it has had on tribal life.

7432 As part of the overall CRSO EIS process, the tribes have made clear the importance of
7433 presenting with clarity the effects the operations and maintenance of the CRS has had on every
7434 facet of tribal culture, both good and bad, since its earliest development. An obstacle to this
7435 effort, which was expressed in many forums during consultation between the Federal agencies

7436 and the Tribes, was that the Federal agencies failed to understand the holistic connections
7437 between natural resources, cultural resources, and the everyday practice of tribal lifeways. This
7438 was reflected, they contended, in the agencies' adoption of a definition of "cultural resources"
7439 that focused on properties, as suggested by the National Historic Preservation Act, versus a
7440 more holistic definition of cultural resources that sees a much broader range of phenomena as
7441 cultural resources. For example, several tribes claimed that fish, which are a key part of many
7442 Native American ceremonies in the Pacific Northwest, are just as much of a cultural resource as
7443 an archaeological site or a historic building. This reliance on a property-based definition of
7444 cultural resources is just one example of how the perspective adopted by the agencies is
7445 fundamentally at odds with most indigenous peoples' learning systems.

7446 While providing quantitative descriptions of the effects the operations and maintenance of the
7447 CRS has had on their communities, the tribes have also provided qualitative accounts of these
7448 effects. Qualitative research may be described as "any type of research that produces findings
7449 not arrived at by statistical procedures or other means of quantification" (Kovach 2009, 26)
7450 which tends to be interpretative, contextual, and narrative in nature. Attempting to capture
7451 concepts arrived at through this process, and insert them into a system based on a traditional,
7452 positivist quantitative system, based on the empirical investigation of observable phenomena
7453 via statistical, mathematical, or computational techniques, has historically been a challenge
7454 whenever traditional knowledge-based systems are incorporated into empirical studies. This
7455 has also been true for this CRSO process.

7456 This difference in approach was further highlighted when discussing two property types of
7457 fundamental importance to the tribes: sacred sites and Indian Trust Assets. Frustrated at the
7458 agencies' decision to focus on cultural resources as properties, many of the tribes pointed to
7459 their cultural belief system, which calls for a holistic world view and allows for a far broader
7460 definition of what they consider as cultural resources. As part of this dialogue, it became
7461 apparent that there was a need to address a third type of property-based tribal resource not
7462 covered by these headings, and so the tribes were invited to "identify aspects of the affected
7463 environment that may not fit under the umbrella of Federal agency regulation resource
7464 definitions of sacred sites and Indian trust assets" which could include "but were not limited to,
7465 resources of cultural importance, traditional areas, gathering and hunting sites, treaty rights,
7466 executive order rights, environmental justice, and other resources." These submittals are
7467 included verbatim together as an appendix of the EIS (Appendix P, *Tribal Perspectives*), with this
7468 EIS section intended to introduce them and provide a general overview of each one.

7469 Following the dissemination of this invitation and subsequent consultation between the co-lead
7470 agencies and tribes, it was decided that, in addition to providing a tribal perspective which
7471 would address these resources, the tribes could provide a qualitative statement in keeping with
7472 standard EIS investigative models to describe effects to tribal people, and that the relevant
7473 portions of this statement would be referenced and included under the appropriate affected
7474 environment section of the EIS. Eleven tribal governments responded to the invitation to
7475 submit a tribal perspective. These tribes were, the Coeur d'Alene Tribe, the Confederated
7476 Tribes of the Colville Reservation, the Confederated Salish and Kootenai Tribes, the

7477 Confederated Tribes of Grand Ronde, the Kootenai Tribe of Idaho, the Spokane Tribe of Indians,
7478 the Confederated Bands and Tribes of the Yakama Nation, the Confederated Tribes of the
7479 Umatilla Indian Reservation, the Nez Perce Tribe, the Confederated Tribes of the Warm Springs
7480 Reservation of Oregon, and the Shoshone-Bannock Tribes.

7481 What follows below is a brief discussion of some general themes frequently encountered during
7482 consultation with the tribes, followed by a summary of all the tribal perspectives received.
7483 Where quotation marks are used, the quote is taken directly from the tribal perspective
7484 submittal received.

7485 **3.17.2.2 General Overview and Common Themes**

7486 It must be stated from the offset that the purpose of this section is to identify themes that were
7487 common to all or most of the tribal perspectives that were submitted and is not an attempt to
7488 lump them all together and reduce multiple tribal voices to one. Nor is it an attempt to speak
7489 on behalf of the tribes; each tribe has spoken for itself.

7490 **IMPACTS TO TRIBAL CULTURE**

7491 It is difficult to overstate the effects each dam's construction and operation has had to tribal
7492 culture, lifeways, and traditions. They have shaken the very foundations of tribal identity and
7493 have either undermined or destroyed aspects of tribal culture central to the very concept of
7494 being an indigenous person in the Pacific Northwest. These effects have been explicit—the loss
7495 of celebrated fishing sites of regional importance such as Celilo and Kettle Falls; and implicit—
7496 the loss of the innumerable and unquantifiable intra- and inter-tribal interactions that occurred
7497 at these locations; loci-focused ceremonies, traditions, language and customs, dances and song.
7498 The loss of these areas has adversely affected how tribal communities define themselves,
7499 interact with each other, and live full spiritual lives; and in the process has undermined the
7500 processes through which living cultures are nourished, maintained and perpetuated. To put it in
7501 terms best understood by non-native people, their loss was not just the loss of a fishing place
7502 and traditional foods, but equates to the loss of the marketplace, the town hall, the
7503 courthouse, and the cathedral.

7504 Many of the tribes have not only lost access to traditional places, but have lost access to the
7505 one thing that all these places had in common, which bound them together and without which
7506 they may never even have existed: the salmon. For many of the tribes, any discussion on the
7507 operations and maintenance of the CRS that does not include a meaningful discussion on how
7508 to return or improve salmon numbers is meaningless.

7509 The loss of these foundational aspects of tribal culture has manifested itself across tribal
7510 communities in very tangible ways. The tribes cope with levels of poverty, ill-health, and
7511 unemployment at significantly higher proportional rates than any other ethnic group in the
7512 country, which in turn leads to significantly higher mortality rates in comparison to non-native
7513 communities. These issues are almost entirely the result of the loss of salmon and other

7514 traditional foods, the loss of tribal lands, intergenerational trauma, assimilation, and the loss of
7515 tribal cohesion.

7516 Just as it is difficult to overstate these effects, it is equally difficult for non-native people to
7517 understand the effects tribal communities have suffered with the development of the CRSO.
7518 Combined with numerous historical events (encroachment of non-native settlers on aboriginal
7519 lands, industrial over-fishing on the Columbia, extensive changes to historical ecosystem-based
7520 function, etc.) the cumulative effect has had severe and existential effects on tribal culture and,
7521 particularly in the mid-twentieth century, pushed tribal cohesion to the verge of extinction.

7522 **Study Period**

7523 There was some variation among the tribes with regard to the period of study addressed by the
7524 EIS. Some argued the baseline against which to measure the effects of the CRSO should be
7525 before the dams came into existence; others stated that natural conditions should be considered
7526 those that existed at the time treaty rights were negotiated and agreed; while others again
7527 insisted that time immemorial should be the measure against which the CRSO is placed. One
7528 thing they all agree on is that the date selected, 2016, is arbitrary and limiting the study to that
7529 time period omits many key actions the cumulative effects of which continue to be felt.

7530 **Coeur d'Alene Tribe Tribal Perspective Summary**

7531 The following is a summary of the submittal received from the Coeur d'Alene Tribe titled
7532 "Affected Environment and Tribal Perspective for the CRSO EIS" sent December 10, 2018
7533 (Appendix P):

7534 Two of the dams in the CRSO, the Chief Joseph and Grand Coulee dams, were "intentionally
7535 created without a way for salmon to safely pass over them." This decision "has decimated the
7536 salmon runs into our usual and accustomed harvesting locations and the present-day refusal to
7537 address this problem results in the continued blockage of descendant salmon."

7538 Salmon are considered a cornerstone of cultural importance to the Coeur d'Alene people
7539 (Schitsu'umsh); not just the actual fish and their consumption, but also the customs and
7540 practices that existed around the harvesting of them. Their harvest "required a detailed
7541 knowledge of nets, weirs and spears constructed of specific materials derived from often
7542 unique species of plants and animals. As a result... it was important... to interface with their
7543 environment and know where [to] access these important materials."

7544 This activity central to the cultural survival of the Schitsu'umsh necessitated "various tribal
7545 events, outings, and ceremonies permeated throughout the year, further strengthening the
7546 tribe's sense of place, community and identity." In addition to this intra-tribal activity, these
7547 activities resulted in establishing and improving inter-tribal relations because "harvesting
7548 occurred in locations shared by other tribes.... [and] brought our friendly, neighboring tribes...
7549 to a single location." These gatherings would include various and simultaneous cultural

7550 interactions, such as dancing and celebrations, contests, inter-tribal marriages, etc., all of which
7551 contributed to and strengthened Schitsu'umsh, tribal identity.

7552 The loss of salmon has served to undermine these activities which once established the
7553 Schitsu'umsh sense of tribal identity which in turn has led to the negative consequences of not
7554 effectively establishing identity. Statistics for reservations (i.e. poverty, suicide, substance
7555 abuse, etc.) can be attributed to the impacts to a people that are struggling with identity. This
7556 brings to light the value in providing a qualitative analysis because some things cannot be
7557 measured; "In other words, the true impact of the CRSO to the CDA tribe cannot be measured."

7558 Following the submittal of their original tribal perspective section, the Coeur d'Alene Tribe
7559 provided an additional section titled "Supplement Information on Tribal Perspective for the
7560 CRSO," which was sent April 30, 2019.

7561 This supplement went on to describe the original traditional aboriginal territory of the
7562 Schitsu'umsh, and the changes to it resulting from their interaction with the peoples and
7563 government of the United States. This interaction resulted in the reduction of their original
7564 territory from "more than 5 million acres" in pre-contact times, to a reservation 334,471 acres
7565 in size, of which less than one fifth is in tribal ownership.

7566 Schitsu'umsh traditional culture is seasonally based and centered on fishing which took place
7567 throughout the year. In their own words, "the history of the dam building era marks a decades
7568 long progression during which the Coeur d'Alene Tribe was systematically removed from the
7569 anadromous resources that were available to their ancestors" due to the drainages relied upon
7570 by the Tribe for anadromous fish harvest being adversely impacted by dam construction and
7571 operation: "The loss of these habitats to anadromous fisheries has had a significant and
7572 continuing impact on the Coeur d'Alene Tribe's cultural, economic and social well-being."

7573 The effects of this loss have rippled across all aspects of tribal life and have been made manifest
7574 in specific symptoms.

- 7575 • Current fish consumption rates are a tiny fraction of historic levels largely due to the
7576 construction and subsequent inundation by the dams. Operational impacts continue to
7577 denude critical downstream habitat in areas where salmonid recovery is tenuous.
7578 Secondary impacts may include un-quantifiable resource impacts such as: disrupted
7579 migration routes of large game and subsequent impacts to herd health and availability.
- 7580 • The loss of salmon has been identified by the Tribe as an impact of historic trauma, which
7581 has included the loss of language, land base and culture, contributing to what psychologist
7582 Dr. Eduardo Duran has termed a "soul wound."
7583 "This wound exists at the community level, where generations of loss require an
7584 attention to collective grief that requires collective solutions to heal. The failure of
7585 western public health interventions to change the trajectory of health disparities in
7586 Indigenous communities 'reflects a non-engagement with the social/cultural drivers of
7587 health and the subsequent application of inappropriate intervention models.'"

7588 The supplement provides copious references to studies of American Indian/Alaska Native
7589 populations, all of which show disproportional rates of death attributed to quality of life, diet,
7590 poverty, and lack of education due to a scarcity of resources. One study cited includes the
7591 report titled *Tribal Circumstances & Impacts from the Lower Snake River Project on the Nez*
7592 *Perce, Yakama, Umatilla, Warm Springs, and Shoshone Bannock Tribes* (“Tribal Circumstances
7593 Report”), which was prepared by Meyer Resources, Inc., on behalf of the Columbia River Inter-
7594 Tribal Fish Commission with funding from the U.S. Army Corps of Engineers for the NEPA
7595 process for the Lower Snake River dams. The Tribal Circumstances Report identifies impacts to
7596 tribal income/health, life-support resources, and economic base from the status quo operations
7597 of the Snake River dams. The supplement indicated that these disproportionate impacts to the
7598 economic base, community health and loss of culture are relevant to the Coeur d’Alene Tribe in
7599 regard to the impacts of the CRSO.

7600 The studies and information provided by the Coeur d’Alene Tribe identify that a clear link exists
7601 between these issues, and the impacts the CRSO has had on tribal culture, society, and life.
7602 “The cumulative effects of dam construction have transferred potential wealth produced in the
7603 river basin from the salmon on which the tribes depend to electricity production, irrigation of
7604 agriculture, water transport services and waste disposal, these latter primarily benefiting non-
7605 Indians. These transfers have been a significant contributor to gross poverty, income and health
7606 disparities between the tribes and non-Indian neighbors.”

7607 **Confederated Tribes of The Colville Reservation Tribal Perspective Summary**

7608 The following is a summary of the submittal received from the CTCR, titled “Tribal Perspectives,
7609 Traditional Places, and the Federal Columbia River System” sent March 4, 2019, and presented
7610 in full in Appendix P:

7611 CTCR believes that language, songs, ceremonies, rituals, traditional ecological knowledge,
7612 religion, legends, cultural expressions, settlement and subsistence patterns, intergenerational
7613 knowledge transmission, and other intangible facets of humanity shape the belief, expression
7614 and practice of their tribal communities and histories.

7615 These intangible facets are essential to maintaining the continuing cultural identity of the
7616 tribes. The impacts of the loss or diminution of these cultural ways are identifiable and can be
7617 documented historically, quantitatively, and qualitatively. They are cumulative in origin and
7618 result from multiple actions, events, and entities. Hence, attributing any one impact to a
7619 particular circumstance, or limiting the chronological examination of multiple impacts to a
7620 particular and arbitrary timeframe, undermines the value of the assessment.

7621 The Tribe acknowledges the quantitative challenge in documenting the causal relationship
7622 between the loss of those intangible, non-property-based aspects of culture to specific
7623 undertakings. Analysis provided by CTCR showed qualitative impacts of how participation in
7624 cultural activities have been forced to adapt to physical conditions brought on by changes to
7625 the landscape caused by the Federal policies and directives of the CRSO. For example, it was
7626 expressed that intergenerational transmission of language, knowledge, and traditional ways are

7627 being lost, and that “if ceremonies are not conducted, then language is not spoken as often,
7628 legends are not told, family history is forgotten, ritual practices are lost, and the status and role
7629 of the elders are diminished.”

7630 Nineteen dams and their corresponding reservoirs affect traditional use areas of the CTCR
7631 constituent tribes and bands, including the continued total blockage of anadromous salmonids by
7632 the construction of Grand Coulee and Chief Joseph dams. This “devastation of the Tribes’
7633 ancestral fisheries caused (and continues to cause) irreparable harm to the culture, subsistence,
7634 religion, health, social structure, and economy of all twelve constituent tribes and bands.” Climate
7635 science projections will continue to adversely impact anadromous species, their potential
7636 habitats, and CTCR’s concerted efforts to reintroduce salmon into the upper Columbia River.

7637 The boundaries of the Colville Reservation were defined with the intent to include fisheries
7638 important to the tribes assigned to the Reservation. The completion of the Grand Coulee Dam,
7639 and later the Chief Joseph Dam, inundated these fisheries and the regionally important fishery
7640 at Kettle Falls and, more significantly, prevented salmon and other anadromous species from
7641 reaching much of the Colville Reservation lands, and the lands and waters of the former North
7642 Half of the reservation, rendered as public domain in 1891, to which CTCR members retain
7643 federally protected reserved hunting, fishing and gathering rights. Consequently, the Tribe’s
7644 food system and subsistence fishing economy has been destroyed along with the diminishment
7645 of “many of the cultural traditions associated with salmon fishing.”

7646 In addition to the loss of fish, inundation, transmission, irrigation projects associated with the
7647 CRS have significantly and substantially affected the traditional food system, collective health,
7648 and subsistence harvesting economy of the CTCR; particularly the unrestricted access to and
7649 gathering of traditional cultural plants. Other tribal resources adversely affected by the CRS
7650 consist of, but are not limited to:

- 7651 • Graves and cemeteries
- 7652 • Springs associated with cultural places and ceremonial activities
- 7653 • Fishing stations
- 7654 • Hunting areas
- 7655 • Plant food, medicine, fiber, and material gathering areas
- 7656 • Vision quest sites
- 7657 • Ceremonial locations, e.g., prayer sites, sweathouses, traditional dance locations, vision
7658 questing sites and prehistoric sites identified as containing features such as rock rings,
7659 cairns, and certain types of talus pits are associated with ritual activity
- 7660 • Traditional sites
- 7661 • Named places, i.e., locations that have been given a Native language name
- 7662 • Legendary locations associated with traditional legends or stories
- 7663 • Mineral procurement areas

7664 The CTCR ends their supplemental analysis by stating they have no preferred alternative for the
7665 CRSO EIS with respect to the protection of cultural resources:

7666 “Selection of any of the alternatives put forth within Iteration 2 of the Columbia River
7667 System Operations EIS will not lessen the continued diminishment and destruction of
7668 cultural resources and the traditional food system of the Colville Reservation and other
7669 areas in the tribes’ traditional territory that are vitally important to the CTCR.”

7670 **Confederated Salish and Kootenai Tribes Tribal Perspective Summary**

7671 The following is a summary of the submittal received from the Confederated Salish and
7672 Kootenai Tribes (CSKT) titled “CRSO Statement of the CSKT” sent May 9, 2019, and presented in
7673 full in Appendix P:

7674 The CSKT assert that “from time immemorial the aboriginal homeland of the Confederated
7675 Salish and Kootenai Tribes of the Flathead Reservation reached from what is now British
7676 Columbia, down through parts of what are now the states of Idaho, Montana and Wyoming,
7677 including the Greater Yellowstone Area.” Within this area, no natural resource is more vital to
7678 them as a people than water, the importance of which is woven into all aspects of tribal life.
7679 Their place on the land and the importance of water to their tribal lives are encapsulated in
7680 their recognized Treaty rights and “interests within and to waters and lands that coincide with
7681 hydropower facilities and reservoirs of the Federal Columbia River Power System.” Specifically,
7682 the Kootenai River and the Flathead River systems which include Libby Dam and Hungry Horse
7683 Dam, respectively, and their associated reservoirs; Lake Kocanusa and Hungry Horse Reservoir.

7684 Under the Hell Gate Treaty of 1855, the Tribes retained certain rights on ceded aboriginal
7685 territory, including, among other things, the right of taking fish at all usual and accustomed
7686 places, in common with the citizens of the Territory. Thus, the Tribes assert, and courts have
7687 long recognized, that for all Columbia River tributary streams located in the State of Montana
7688 the CSKT retain either an exclusive or shared right to manage and use the fishery and other
7689 resources. As a result, the Federal action agencies must consider the significant effects, among
7690 other things, that “FCRPS operations will have on Tribal waters when proposing Hungry Horse
7691 Reservoir drawdowns to support flow augmentation for anadromous fish, because these flows
7692 will pass through the Flathead Indian Reservation and accordingly, by timing and volume, affect
7693 Tribal water quality.”

7694 The Tribe concludes by stating that “Libby Dam, Hungry Horse Dam, and their associated
7695 reservoirs inflicted many other serious impacts on the culture, resources, and economy of the
7696 CSKT. They caused the inundation of traditional use sites, cultural sites, and archaeological
7697 sites.”

7698 **Confederated Tribes of Grand Ronde Tribal Perspective Summary**

7699 The following is a summary of the submittal received from the Confederated Tribes of Grand
7700 Ronde (CTGR) titled “Blueprint for Characterizing Tribal Cultural Landscapes (TCLs) in the Area

7701 of Potential Effect (APE) of the Columbia River System Operations Environmental Impact
7702 Statement (CRSO EIS)” which was sent April 26, 2019, and presented in full in Appendix P:

7703 In their submittal the Confederated Tribes of Grand Ronde provided a blueprint for developing
7704 the protocols for resource identification and analysis of tribally important resources. Tribally
7705 important resources, or Tribal Cultural Landscapes (TCLs), are defined as “any place in which a
7706 relationship, past or present, exists between a spatial area, resource, and an associated group
7707 of indigenous people whose cultural practices, beliefs, or identity connects them to that place”
7708 and can only be defined as significant by tribes and indigenous communities, rather than by
7709 exterior criteria. This is a fundamental difference between TCLs and Section 106 TCPs.

7710 This approach recognizes that each “tribe or indigenous group has a unique set of traditional
7711 knowledge and lifeways which are inextricably connected to places on the landscape. A group
7712 of tribes may all have connections to the same geographic area or overlapping geographic
7713 areas, and their connections may differ widely. Therefore, the same geography may carry a
7714 vast, wide array of associated tribal resources and knowledge.” In keeping with the qualitative
7715 tradition, Tribal cultures tend not to separate natural, cultural, historical, ethnographic,
7716 archaeological, ecological, spiritual, and subsistence resources from each other in terms of
7717 labels or categories. The same location or species may have multiple levels of TCL importance
7718 to a single tribe and information specific to a TCL should only come from that tribe.

7719 The CTGR project staff offered this approach “as an alternative means for tribes to identify,
7720 gather, and use (and share with others as determined appropriate by the tribe) meaningful
7721 information on tribally important places and resources potentially impacted by CRSO-EIS
7722 alternatives.”

7723 **Kootenai Tribe of Idaho Tribal Perspective Summary**

7724 The following is a summary of the submittal received from the Kootenai Tribe of Idaho and is
7725 titled “Kootenai Tribe of Idaho Perspectives on the Columbia River System Operations” and was
7726 sent April 26, 2019, and presented in full in Appendix P:

7727 The perspective begins with the statement that “Kootenai Elders and oral Historians say that
7728 much of their very early history, including Creation and the beginning of time, is so uniquely
7729 Kootenai and so sacred that it cannot be shared with outsiders.” They have consented to
7730 provide the following information:

- 7731 • “There is a Creator who made the world.
- 7732 • You call the Creator God; He told us to call Him Nupika.
- 7733 • He made different people for different places.
- 7734 • He made the Kootenai People for this place.
- 7735 • ‘I am your Quilxka Nupika, your supreme being. I have no beginning and no end. I have
7736 made my Creation in my image – a circle – and you Kootenai people are within that circle
7737 along with everything else in my Creation.

- 7738 • Remember that everything in my Creation is sacred, and is there for a purpose. Treat it well.
7739 • Take only what you need, and waste nothing.
7740 • Don't commit murder.
7741 • Respect and help one another.
7742 • Cherish your children and your old ones – They are your future and your past.
7743 • Your word must always be good. Never lie, never break a promise.
7744 • At all times, pull together – act with one heart, one mind.
7745 • I have created you Kootenai People to look after this beautiful land, to honor and guard and
7746 celebrate my Creation here, in this place. As long as you do that, this land will meet all your
7747 needs. Everything necessary for you and your children to live and be happy forever is here,
7748 as long as you keep this Covenant with me. Will you do that?"

7749 The heart of Ktunaxa (Kootenai) Territory is the Kootenai/y River and its tributaries. Libby Dam,
7750 which became operational in 1974, is part of the CRSO. The Kootenay River is also impounded
7751 by Corra Linn Dam where the west arm of Kootenay Lake flows into the Kootenay River where it
7752 meets the Columbia River. Duncan Dam, also authorized by the Columbia River Treaty and
7753 spanning the Duncan River, also controls flows into Kootenay Lake. "The construction,
7754 inundation and operation of the hydroelectric facilities had a profound impact on Ktunaxa
7755 resources and continues to do so. Nearly all the species Ktunaxa relied on for subsistence and
7756 cultural purposes are threatened, endangered or extirpated." Consequently, the ability of
7757 Ktunaxa people to practice their religion and culture is impeded by the CRSO; however, the
7758 CRSO EIS analysis focuses solely on resources in the United States. The Ktunaxa maintain that
7759 "it is impossible to fully analyze impacts to Ktunaxa resources with this artificial limitation."

7760 **The Shoshone-Bannock Tribes Tribal Perspective Summary**

7761 The following is a summary of the submittal received from the Shoshone-Bannock Tribes (the
7762 Tribes) and is titled "RE: Formal submittal of the Shoshone-Bannock Tribes 'Tribal Perspectives'
7763 section for the upcoming CRSO Draft Environmental Impact Statement," sent April 30, 2019.
7764 The Shoshone Bannock Tribes recommend the reader review the complete Tribal perspective
7765 found in Appendix P, due to the limitations of offering a complete dissertation in the following
7766 summary section.

7767 The Tribes believe this document represented "a significant opportunity to promote the
7768 conservation of our Tribes' trust resources and the preservation of our salmon culture for future
7769 generations" given their "unique view of the issues surrounding anadromous fish management in
7770 the context of the operations of the System." The underlying basis of their perspective is the
7771 belief that it is time to select an alternative that restores the systems and affected unoccupied
7772 lands to a natural condition and as such state "the nearest alternative to this perspective would
7773 be for the co-lead agencies to select and implement Multiple Objective - 3 (MO3)."

7774 Their desire to see a return to natural conditions stems from the Tribes' "reliance on the natural
7775 riverine ecosystem of the Columbia River Basin for subsistence since time immemorial" which

7776 they consider to be enshrined, recognized, and guaranteed, through the Treaty reserved right
7777 to hunt on unoccupied lands of the United States. The Tribes hold that their rights and interests
7778 are directly impacted by the operation, maintenance, and configuration of the System.

7779 The Tribes explained that, because their approach to addressing issues stemming from the
7780 CRSO are stymied by “the boxes of National Environmental Policy Act ... and our expanded
7781 definitions of Indian Trust Assets and Cultural Resources cannot be heard[,] we feel that the
7782 Tribal Perspective section is a welcomed opportunity to express our values, concerns, and risks
7783 to the Tribes[’] culture and Treaty reserved rights.”

7784 The Tribes state that the continued existence of their culture is at risk due to the environmental
7785 inequities that have been forced upon them since first contact with non-native settlers in the
7786 region. They also state that equitable distribution of environmental risk and benefits has not
7787 been afforded to the Tribes, who instead have been “forced to shoulder the burdens of
7788 conservation. Because what is at stake now is our Treaty reserved subsistence lifestyle.”

7789 In this perspective, the Shoshone and Bannock Peoples’ reiterate and refer to what they consider
7790 their “Culture of Stewardship” cemented in their relationship with the land since time
7791 immemorial, the aim of which is that “Tribal members will have the opportunity to harvest salmon
7792 using both traditional and contemporary methods on populations that are sustainable, resilient,
7793 and abundant.” The Fort Bridger Treaty of 1868 was negotiated and then ratified by Congress in
7794 1869, which reaffirmed the permanent home and reserved off-reservation rights: “they shall have
7795 the right to hunt on the unoccupied land of the United States so long as game may be found
7796 thereon, and so long as peace subsists among the whites and Indians on the borders of the
7797 hunting districts.” And that “[p]ersistent today is an instinct to return to the fisheries, resource
7798 patches, and lands to continue the heritage of the Shoshone and Bannock peoples.”

7799 It is the Tribe’s position that the management direction taken by this environmental evaluation
7800 will have a significant impact on the Tribes and their cultural resources. Continuation of
7801 traditional cultural practices in modern day requires the use of technical innovation combined
7802 with essentials of tradition. Tribal identification is found by practicing traditional principles that
7803 mirror the images of their ancestors hunting anadromous fish and gathering and giving thanks
7804 for the blessings.

7805 In their submittal, the Tribes disagreed with the definition of cultural resources provided under
7806 NEPA and Section 106 of the NHPA, and expanded this definition to include “all elements of
7807 mind, spirit, and physical being; all are inextricably tied to the physical landscape.” This
7808 definition includes archaeological sites, historic sites, traditional cultural practices, spiritual
7809 beliefs, sacred landscapes, intellectual property, subsistence resources, language and oral
7810 tradition, place names, and tribal cultural geography. “The Tribes’ definition of cultural
7811 resources is based in a holistic perspective that encompasses plants, water, animals and
7812 humans, as well as the relationships existing among them.” They go on to state that “a cultural
7813 resource is any resource of cultural character” and that “A culture existence is dependent on
7814 the continuity of interconnected knowledge, beliefs, conventional behavior and technical

7815 practices.” The traditional cultural practices, including the use of riverine resources, are the
7816 foundation on which the Tribes built communities across their homelands for millennia.

7817 While acknowledging the benefits to the region derived from the CRSO, the Tribes assert that
7818 these benefits were paid for in kind and disproportionately at the expense of their community’s
7819 health and well-being while at the same time being expected to “[shoulder] the burden of
7820 conservation in our homelands, and losing an important part of our culture along the way.”

7821 The Supreme Court of Idaho stated that the “special consideration which is to be accorded the
7822 Fort Bridger Treaty fishing right must focus on the historical reason for the treaty fishing right.
7823 The gathering of food from open lands and streams constituted both the means of economic
7824 subsistence and the foundation of a native culture. Reservation of the right to gather food in
7825 this fashion protected the Indians’ right to maintain essential elements of their way of life, as a
7826 complement to the life defined by the permanent homes, allotted farm lands, compulsory
7827 education, technical assistance and pecuniary rewards offered in the treaty. Settlement of the
7828 west and the rise of industrial America have significantly circumscribed the opportunities of
7829 contemporary Indians to hunt and fish for subsistence and to maintain tribal traditions. But the
7830 mere passage of time has not eroded the rights guaranteed by a solemn treaty that both sides
7831 pledged on their honor to uphold. As part of its conservation program, the State must extend
7832 full recognition to these rights, and the purposes which underlie them.” Following on from this
7833 the Tribe asserts that “while the Action Agencies utilize a generic definition of Indian Trust
7834 Resources, the Tribes view every salmon as a trust asset that should be collectively managed to
7835 sustain our Treaty reserved right to harvest those subsistence foods.”

7836 The Tribes Policy for Management of the Snake River Basin Resources states: “The Shoshone
7837 Bannock Tribes will pursue, promote, and where necessary, initiate efforts to restore the Snake
7838 River systems and affected unoccupied lands to a natural condition.” Though there were other
7839 factors involved, such as commercial over-fishing, populations of salmon decreased
7840 substantially with the construction of hydroelectric dams on the Lower Snake and Columbia
7841 rivers. The Tribes regard it as their “obligation as managers and stewards of these resources
7842 from time immemorial... on the best manner to operate the System and ultimately, recover
7843 anadromous fish species to sustainable and harvestable levels” and as such they seek the
7844 “restoration of component resources to conditions that most closely represent the ecological
7845 characteristics and processes associated with a natural riverine ecosystem.”

7846 Continuing the Tribes’ view of their culture of stewardship, they view their work to restore the
7847 ecosystem to its natural condition as an essential element in the fight against, and to
7848 counteract, the effects of climate change, whose “impacts have the potential to affect the
7849 entire Basin and resources the Tribes stewarded from time immemorial.” Climate change
7850 presents a threat to critical cultural resources, thereby also threatening the lifeways and
7851 wellbeing of the Tribes. The Tribes view the CRSO, particularly through impacts from slack-
7852 water reservoirs and a loss of riverine ecosystem structure and function, as contributors to
7853 climate change.

7854 All these factors, combined with changes to the energy market in the Pacific Northwest,
7855 culminates in the Tribes presenting an argument in favor of breaching the dams on the Lower
7856 Snake River, a move they believe will be of net gain to the region. “The Tribes recognize the
7857 benefits that hydropower facilities have had in developing industries and providing electricity to
7858 customers in rural areas. However, these benefits were accrued at the expense of fisheries
7859 across the Basin, with impacts to Tribal communities who had relied on their presence for
7860 millennia” and that “An objective evaluation of these economic conditions would speak
7861 strongly in favor of divesting the Snake River component of the System and allow free-flowing
7862 river conditions to drive recovery processes for wild anadromous fish stocks in our homelands.”

7863 Consequently “The Tribes endorse the selection and implementation of Multiple Objective
7864 Alternative 3, which includes the removal of earthen embankments and adjacent structures
7865 within the lower four Snake River dams.”

7866 **The Nez Perce Tribe, the Confederated Tribes and Bands of the Yakama Nation, The**
7867 **Confederated Tribes of the Warm Springs Reservation, and the Confederated Tribes of the**
7868 **Umatilla Indian Reservation Tribal Perspective Summary**

7869 The Nez Perce Tribe (NPT), the Confederated Tribes and Bands of the Yakama Nation (YN), the
7870 Confederated Tribes of the Warm Springs Reservation (CTWSR), and the Confederated Tribes of
7871 the Umatilla Indian Reservation (CTUIR), collectively to be referred to as the Lower River Treaty
7872 Tribes (LRTTs), with the help of their Columbia River Inter-Tribal Fish Commission, submitted a
7873 joint Tribal Perspective which took the 1999 “Tribal Circumstances and Impacts of the Lower
7874 Snake River Project on the Nez Perce, Yakama, Umatilla, Warm Springs and Shoshone Bannock
7875 Tribes” (the Meyers report) as a foundation to outline tribal concerns and perspectives of the
7876 project’s effects on “tribal resources, interests, and culture,” sent June 11, 2019, and presented
7877 in full in Appendix P.

7878 It should be noted that three of the four tribes participated as cooperating agencies, with the
7879 caveat that the tribes do not endorse the DEIS by virtue of their participation as cooperating
7880 agencies and still intend to provide public comments once the document is released.

7881 The LRTTs Tribal Perspective Submittal provides a substantial overview and thorough
7882 background of their treaty-reserved rights to take fish at “usual and accustomed places,” which
7883 have been confirmed and upheld in key Federal and Supreme Court rulings.

7884 Furthermore, the LRTTs reaffirm that at the time of treaty signing, the tribes understood that
7885 through the treaties, the United States was securing the tribes’ food. The CRSO doesn’t just
7886 impact tribal interests, it impacts tribal interests that are secured by treaties with the United
7887 States. This concept (along with the proposition that the baseline for measuring effects in the
7888 CRSO analysis should be the time of treaty signing) is the heart of the LRTTs document; “...My
7889 strength is from the fish; my blood is from the fish, from the roots and the berries. The fish and
7890 the game are the essence of my life.” The Report also described the importance of salmon to
7891 the cultural well-being of tribal people and their sense of belonging to their culture and being
7892 part of traditions that define themselves as Indian people as well as their self-esteem as
7893 members of their tribes and fulfilling their cultural obligations. The Meyer Report also used

7894 tribal poverty, tribal unemployment, tribal per capita income, tribal health and tribal assets as
7895 more traditional indicators of tribal well-being which have been severely impacted by dam
7896 construction and exacerbated by operations.

7897 The LRTTs state that the “Columbia and lower Snake river dams transformed the production
7898 functions of the federally impounded portions of the Columbia and Snake rivers - taking
7899 substantial treaty-protected wealth in salmon away from the tribes. At the same time, the
7900 dams increased the wealth of non-Indians through enhanced production of electricity,
7901 agricultural products, transportation services, flood control, and other associated benefits. As
7902 thoroughly documented in the Meyer Report, tribal peoples have not shared in this increased
7903 wealth on a commensurate basis. Moreover, the tribes did not share commensurately in the
7904 fisheries mitigation that did occur.”

7905 Through reference to several previously produced documents, the LRTTs point out the lengths
7906 to which they have gone to facilitate the restoration of salmon numbers and by including these
7907 initiatives the LRTT seek to demonstrate that the tribes’ perspective is to prioritize salmon
7908 restoration (the 2014 “Wy-Kan-Ush-Mi Wa-Kish-Wit”; the Columbia River Treaty Tribes’ Spirit of
7909 the Salmon Plan; “CRITFC, White Sturgeon Hatchery Master Plan: Lower Columbia and Snake
7910 River Impoundments, Step 1 Revised” December 15, 2015; the YN annual Status and Trends
7911 Annual Report (STAR); the 2013, NPT “Fisheries Management Plan, 2013-2028”; and the 2008
7912 CTUIR River Vision). Similarly, they emphasize the importance of this as evidenced by the work
7913 of non-tribal entities that complement the tribal “visions” (Columbia Basin Partnership Task
7914 Force, A Vision for Salmon and Steelhead: Goals to Restore Thriving Salmon and Steelhead to
7915 the Columbia River Basin [Phase 1 Report to the NOAA Fisheries Marine Fisheries Advisory
7916 Committee], Final Draft Report [March 28, 2019]; The 2014 Columbia River Basin Fish and
7917 Wildlife Program; the Accords Agreement).

7918 The LRTTs Tribal Perspective document highlights two topics that underpinned the 1999 Meyer
7919 Report: the abundance of focal fish species and effects of the Federal hydro system on
7920 anadromous fish survival. Adult salmon, sturgeon and lamprey abundance, and tribal harvest,
7921 are still far removed from historical levels. The LRTTs Tribal Perspective document provides in-
7922 depth discussion of salmon abundance, smolt to adult survival rates, reach survival, CRSO DEIS
7923 alternatives, and juvenile salmon reach survival. The LRTTs request that the TP be read in full,
7924 presented in Appendix P.

7925 The LRTTs insist “The DEIS must respect the Columbia River Treaty Tribes’ culture, food, and
7926 ways of life” and that “Fish and wildlife conservation, compliance with environmental laws and
7927 addressing Tribes’ treaty rights go hand in hand.”

7928 The LRTTs make clear that they feel the analysis of the EIS is limited as it does not adequately
7929 address other fish stocks such as Columbia yearling Chinook salmon and steelhead.

7930 **Spokane Tribe of Indians Tribal Perspective Summary**

7931 The following is a summary of the submittal received from the Spokane Tribe of Indians and is
7932 titled “Columbia River System Operation: Tribal Perspective,” sent June 11, 2019, and
7933 presented in full in Appendix P:

7934 This submittal states clearly the connection the Spokane Tribe of Indians has had with the
7935 inland waterways of the Pacific Northwest, specifically the Spokane River, since time
7936 immemorial “The Spokane Tribe of Indians traces a deep and rich history that is tied to inland
7937 northwest waterways, especially the Spokane River. Often called ‘People of the River,’ the
7938 Spokane people have considered the river that bears their name a sacred place that provided
7939 food and a place to call home.”

7940 This long association with the waterways, and inhabitation of their associated hinterlands, has
7941 resulted in the establishment of strong cultural and societal links between the Spokane Tribe of
7942 Indians and these rivers “The locale contains dozens of significant and irreplaceable ancestral
7943 cultural sites, both sacred and profane. The importance of these sites lies not only in the
7944 artifacts themselves, but in the history contained within the objects (singly and collectively),
7945 features, pictographs, and landscapes. Moreover, hundreds, if not thousands of Spokane
7946 ancestors were laid to rest along this waterway and many of them remain here.” As a result of
7947 this close association and symbiotic relationship with these waterways, “the Spokane Tribe
7948 considers the entire Spokane Arm a traditional cultural place.”

7949 **3.17.2.3 Agency Consideration of Tribal Perspectives**

7950 The tribes’ perspectives provide a wealth of information regarding historical and current effects
7951 of the CRS to resources, rights, and interests of the tribes. Combining these perspectives with
7952 the resource specific analyses from this chapter provides agency leadership important
7953 information to consider in the evaluation of a preferred alternative. The following description
7954 of the four MOs and the No Action Alternative summarizes the agencies’ interpretation and
7955 consideration of the tribal input on these alternatives. In Chapter 7, the agencies considered
7956 Tribal Perspectives in formulating the Preferred Alternative.

7957 **NO ACTION ALTERNATIVE (NAA)**

7958 The no action alternative includes the many operational and structural modifications to the CRS
7959 that have occurred over the past several decades. The major focus of these improvements has
7960 been related to improving fish passage and survival, but identification, mitigation, and
7961 protection of cultural resources has been a focus. While many tribes generally acknowledge
7962 there have been improvements relative to earlier configurations and operations, most tribes
7963 have been clear that not enough is being done to adequately protect or mitigate impacts to
7964 tribal interests.

7965 **MO1**

7966 This alternative focuses on several actions intended to benefit anadromous and resident fish
7967 while also including measures for water management flexibility, hydropower production, and
7968 additional water supply. There are benefits to tribal interests under this alternative, but there
7969 are also some localized adverse effects to resident fish in upper basin areas which could be
7970 perceived negatively by tribes in those regions. Like many of the alternatives, MO1 attempts to
7971 balance many interests and improve conditions for fish while maintaining flexibility for the
7972 congressionally authorized purposes. Tribal perspectives, which convey the numerous effects of
7973 the system upon tribes over many decades, suggest this alternative may be viewed as not doing
7974 enough to address tribal interests.

7975 **MO2**

7976 A primary goal of this alternative was to increase hydropower production and reduce regional
7977 greenhouse gas emissions. There are minor to major adverse effects to tribal interests under
7978 this alternative. Both resident and anadromous fish are adversely affected, as are cultural
7979 resources. While this alternative includes several structural measures targeted at improving fish
7980 passage, the operational changes are generally not favorable to tribal interests. Among the
7981 range of alternatives evaluated, this alternative is likely to be the least supported by tribes
7982 based on its potential effects to tribal interests.

7983 **MO3**

7984 This alternative was specifically identified by several tribes as preferable relative to the range of
7985 alternatives analyzed in this EIS. Most tribes support breaching the four lower Snake River
7986 dams. This action most closely resembles the historic, pre-dam condition that supported tribes
7987 since time immemorial. Even with uncertainty regarding the magnitude of effects of dam
7988 breaching to resources, such as anadromous fish, many tribes would likely support this
7989 alternative as it represents the only alternative that substantially attempts to restore the river
7990 to a more natural environment. Additionally, some tribes could interpret dam breaching as a
7991 meaningful milestone in salmon restoration efforts. The co-lead agencies recognize the support
7992 for this alternative by a number of tribes.

7993 **MO4**

7994 This alternative includes the highest spill levels, many structural changes to improve fish
7995 passage, and storage reservoir drawdowns in the upper basin to augment flows for fish in the
7996 lower basin. At the lower Snake and lower Columbia River projects, reservoirs are lowered to
7997 potentially improve fish migration. While this alternative provides a number of expected
7998 benefits to anadromous fish, it could adversely affect other tribal interests including resident
7999 fish (particularly in upper basin areas) and cultural resources. The level of support among tribes
8000 for this alternative likely varies by primary geographic area of interest; upper basin tribes may
8001 be less supportive than lower basin tribes.

8002 **3.17.3 Tribal Interests**

8003 Tribes in the Columbia River Basin have treaty rights, federally reserved rights, and other
8004 interests in the study area and in many of the resources described in Chapter 3. The existing
8005 tribal and reservation structure is largely the result of treaties between the U.S. government
8006 and the tribes during the period of Euro-American settlement of the West. Isaac Stevens,
8007 Washington Territorial Governor, negotiated a series of major treaties with Columbia River
8008 Basin (and Puget Sound) Tribes in 1855 (see Table 3-305). Other treaties followed in the 1860s.

8009 **Table 3-305. Key Treaties with Columbia River Basin Indian Tribes**

Treaty	Tribe(s)
Hell Gate Treaty of July 16, 1855	Flathead (Salish), Pend d’Oreille (Upper Kalispel), Kutenai
Yakama Treaty of June 9, 1855	Confederated Bands and Tribes of the Yakama Nation
Nez Perce Treaty of June 11, 1855 ^{1/}	Nez Perce Tribe
Walla Walla Treaty of June 9, 1855 ^{1,2/}	Cayuse, Umatilla, Walla Walla (all now Confederated Umatilla Tribes)
Treaty of June 25, 1855	Tenino, Wasco (now Confederated Warm Springs Tribes)
Fort Bridger Treaty of July 3, 1868	Shoshone, Bannock

8010 1/ Negotiated at the Walla Walla Treaty Council.

8011 2/ Source: SOR; 2-28 Ruby and Brown, 1992.

8012 These treaties generally were the means by which the tribes ceded tens of millions of acres of
8013 land to the United States in exchange for the creation of reservations and the preservation of
8014 certain rights. The most discussed (and litigated) right is the right to fish, but the treaties
8015 contain other rights as well, including hunting, gathering, pasturing, and travel rights.

8016 A treaty is a contract between sovereign nations. Article VI of the U.S. Constitution recognizes
8017 treaties, along with federal statutes and the constitution of the United States, as the “supreme
8018 Law of the Land.” Treaties can be abrogated (nullified) by Congress, but must be enforced as
8019 long as they remain valid. The treaties bind the Federal government as a whole. The CRSO co-
8020 lead agencies consequently have an affirmative legal duty to comply with the treaties.

8021 The Federal government discontinued formal treaty making with tribes in 1871. Since then, the
8022 government has formally and legally recognized tribes primarily by Executive Order, subject to
8023 approval by both houses of Congress. Though Executive Order tribes cannot share in off-
8024 reservation reserved rights except by specific agreement, their legal status is the same as for
8025 treaty tribes.

8026 Treaty rights and how they have been recognized and practiced has been tested in court since
8027 their adoption. Despite the rights retained by the treaties, there is a long and ongoing history of
8028 litigation to turn that legal formality into on-the-ground reality. This litigation includes a
8029 number of Supreme Court cases over more than a century.

8030 The treaties bind all parties and are the supreme law of the land. The co-lead agencies
8031 recognize and respect that supremacy. As a result, the co-lead agencies will comply with the
8032 treaties, just as they will comply with all other federal laws.

8033 Where it is applicable or pertinent, under certain resources, the co-lead agencies have
8034 attempted to describe how tribal interests would be impacted by the different action
8035 alternatives in various sections of Chapters 3 and 7.

8036 The Cultural Resources, Sacred Sites, and Indian Trust Assets analyses include information and
8037 analysis pertinent to tribes within the study area. By their nature, those sections have robust
8038 discussions of tribal interests and do not have a separate tribal interests section at the end.

8039 **3.18 ENVIRONMENTAL JUSTICE**

8040 **3.18.1 Introduction and Background**

8041 Executive Order (E.O.) 12898, Federal Actions to Address Environmental Justice in Minority
8042 Populations and Low-Income Populations, was issued in 1994.¹ According to the Council on
8043 Environmental Quality (CEQ) guidance for implementing E.O. 12898 under NEPA, “[a]gencies
8044 should consider the composition of the affected area, to determine whether minority
8045 populations, low-income populations, or Indian tribes are present in the area affected by the
8046 proposed action, and if so whether there may be disproportionately high and adverse human
8047 health or environmental effects on minority populations, low-income populations, or Indian
8048 tribes” (CEQ 1997). The CEQ regulations define “human health or environmental effects” to
8049 include economic, environmental, social, cultural, or health-related impacts whether direct,
8050 indirect or cumulative (40 C.F.R. § 1508.8 and CEQ 1997).

8051 EPA defines environmental justice as, “the fair treatment and meaningful involvement of all
8052 people regardless of race, color, national origin, or income with respect to the development,
8053 implementation, and enforcement of environmental laws, regulations, and policies” (EPA
8054 2018).² Environmental justice analyses identify and address, when appropriate,
8055 disproportionately high and adverse effects of Federal agency actions on minority populations,
8056 low-income populations, and Indian tribes. In Chapter 1, Section 1.5 describes the NEPA process
8057 and steps taken to involve the public and coordinate with tribal governments.

8058 Guidance from CEQ for analysis of environmental justice impacts recommends consideration of
8059 the degree to which unique exposure pathways, including subsistence fishing, hunting, or
8060 gathering in minority or low-income populations, may amplify the identified effects of an action
8061 (CEQ 1997). As appropriate, the environmental justice analysis in this EIS will describe unique
8062 conditions of the identified minority populations, low-income populations, and Indian tribes
8063 that may heighten their vulnerability to impacts from the alternatives. Based on guidance
8064 (NEPA Committee and Federal Interagency Working Group on Environmental Justice 2016, 15),
8065 these unique conditions may include these specific vulnerabilities: (1) human health (e.g.,
8066 heightened disease susceptibility, health disparities); (2) socioeconomic (e.g., reliance on a
8067 particular resource that may be affected by the proposed action, disruptions to community
8068 mobility and access as a result of infrastructure development); and (3) cultural (e.g., traditional
8069 cultural properties [TCPs] and ceremonies, fish consumption practices). Section 3.16, *Cultural*
8070 *Resources*, of this EIS describes three property-based categories, including archaeological sites,
8071 TCPs, and historic built resources. Section 3.17, *Indian Trust Assets, Tribal Perspectives and*
8072 *Tribal Interests* captures other resources of tribal interest that do not fit within Section 3.16.

¹ The Executive Order and CEQ guidance was followed by strategic guidance developed by each of the various departments overseeing the co-lead agencies, including the Department of Defense (DOD) Strategy on Environmental Justice of 1995 (DOD 1995), the Department of the Interior (DOI) Environmental Justice Strategic Plan (DOI 2016), and the Department of Energy (DOE) Environmental Justice Strategy (DOE 2017).

² Other agencies, including the DOE in its Environmental Justice Strategy, also recognize this definition of environmental justice.

8073 **3.18.1.1 Area of Analysis**

8074 The study area for the environmental justice analysis is intended to include areas where
8075 minority populations, low-income populations, or Indian tribes may be affected by CRSO
8076 alternatives.

8077 The populations considered in the environmental justice analysis are located in areas that may
8078 be affected by changes to resources potentially impacted including hydropower operations,
8079 rates, or both;³ changes to municipal, industrial, or agricultural water deliveries; changes in the
8080 availability or quality of recreation sites; physical impacts to cultural resources; changes in fish
8081 and wildlife populations; or changes in use of the CRSO areas for navigation and transportation.
8082 The study area for power effects is larger than the study areas for other resources, as the
8083 potential impact from changes in power rates is broader. Counties in which these effects may
8084 occur were identified, resulting in an environmental justice study area comprising 139 counties
8085 across these states: Washington, Oregon, Idaho, Montana, Wyoming, Nevada, and California.
8086 The specific granularity of the environmental justice analysis by resource area is dependent on
8087 the level of detail included in the associated resource-specific analyses in this EIS.

8088 **3.18.2 Affected Environment**

8089 Consistent with E.O. 12898, this section identifies low-income and minority populations within
8090 the study area based on the most recent socioeconomic statistics currently available from the
8091 Census American Community Survey (ACS) 5-year estimates from 2012 to 2016. In this analysis,
8092 census block groups meet environmental justice criteria if more than 20 percent of the
8093 population is below the poverty level or if the percentage of the population that identifies as
8094 minority in the census block group is greater than the percentage of the state which identifies
8095 as minority. Poverty level refers to poverty thresholds, or the dollar amount the Census uses to
8096 determine the poverty status of a person or a family. These thresholds are updated each year
8097 by the Census.⁴ Indian tribes within the study area are also identified.

8098 This section evaluates low-income and minority populations at the census block group level. In
8099 total, there are 8,793 census block groups in the 139-county study area. Census block groups
8100 were selected as the geographic scale of analysis because these block groups provide
8101 comprehensive coverage of the entire study area at the finest level of data available from the
8102 Census for the analysis. A census block group is the smallest geographic area for which the
8103 Census provides consistent sample data. Census block groups contain between 600 and 3,000
8104 people or 240 to 1,200 housing units as statistical divisions of census tracts, which contain

³ The environmental justice study area includes areas within and outside of Bonneville service areas, and both sets of areas are considered.

⁴ The Census poverty thresholds are the same nationwide; with no separate figures for different states, metropolitan areas, or cities. More information about the poverty thresholds is accessed from:
<https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html>.

8105 between 1,200 and 8,000 people. A census block group consists of a contiguous cluster of
8106 blocks within the same census tract (Census 2018a).⁵

8107 Counties within the study area were evaluated by census block group to determine where low-
8108 income and minority populations are present. Data from the 2012–2016 Census ACS was used
8109 to identify census block groups that meet criteria for a low-income population, a minority
8110 population, or both. In addition to low-income populations and minority populations, Indian
8111 tribes were also identified for consideration in the environmental justice analysis based on GIS
8112 information from the Census indicating the location of Indian Reservation and other off-
8113 reservation trust lands included in the study area.⁶

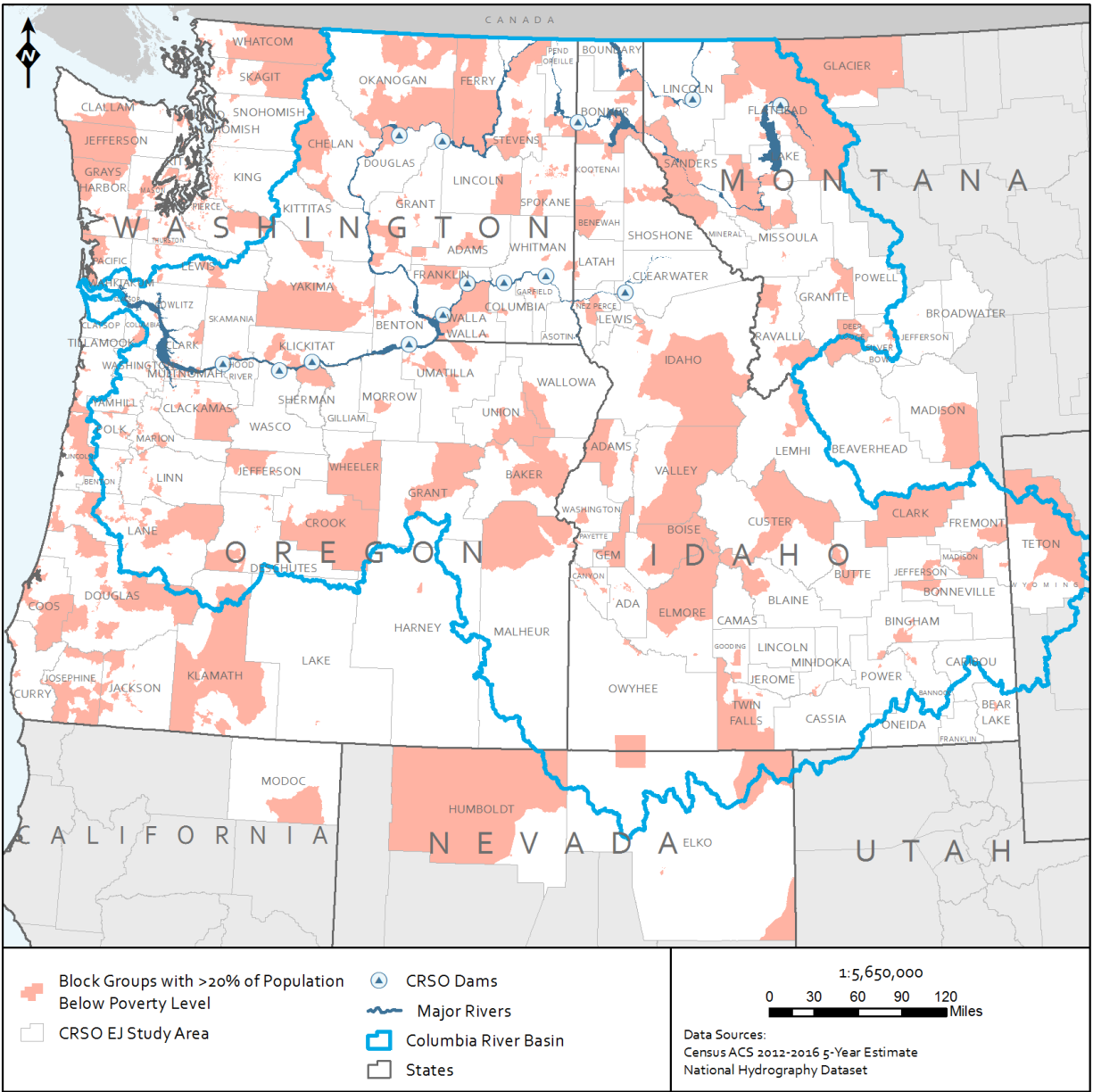
8114 Demographic information for counties and Indian tribes in the environmental justice study area
8115 has been collected from the U.S. Census and is presented in Appendix O, *Environmental Justice*.
8116 This data include metrics typically used by researchers and in EPA’s Environmental Justice
8117 Mapping and Screening Tool (EJSCREEN) to represent the “social vulnerability” characteristics of
8118 a disadvantaged population (EPA 2017).

8119 **3.18.2.1 Identification of Low-Income Populations**

8120 Low-income populations are identified based on the percentage of residents in a census block
8121 group living below the poverty level, where the poverty level refers to the dollar amount the
8122 Census uses to determine the poverty status of a family or a person. The 2016 poverty level (i.e.
8123 poverty threshold) for the United States ranges from \$12,228 for an individual to \$24,563 for a
8124 household of four (Census 2018b). The Census defines a “poverty area” as a census tract or
8125 block numbering area with 20 percent or more of its residents below the poverty level (Census
8126 2016). For this analysis, census block groups for which the Census reports that 20 percent or
8127 more of the population is living below the poverty level are categorized as low-income
8128 populations. Data from the ACS indicating the ratio of income to poverty level for individuals in
8129 a given area were used for this comparison. Areas with an income to poverty level ratio of less
8130 than one fall below the poverty level. Using these data, if the percentage of individuals with
8131 income below the poverty level is greater than 20 percent, the area is considered low income.
8132 Figure 3-229 illustrates census block groups within the study area which are considered low-
8133 income populations for purposes of this analysis. In total, approximately one quarter of census
8134 block groups across the study area (2,226 out of 8,793 total) had more than 20 percent of their
8135 population living below the poverty level in 2016. These low-income census block groups had a
8136 combined population of approximately 3.2 million, which represents approximately one quarter
8137 of the total population of 13.2 million in the study area. A more detailed breakdown of low-
8138 income populations by county is provided in Appendix O, *Environmental Justice*.

⁵ A census block group comprises a reasonably compact and contiguous cluster of census blocks. Block groups are defined by the Census and incorporate input from local agencies and interested data users. Guidelines require that block group boundaries follow clearly visible features such as roads, rivers, and railroads. See 73 Federal Register 13829, March 14, 2008 and Census 1994.

⁶ Additional indigenous peoples and Indian tribes including those that are not currently federally recognized (e.g., Wanapum and Chinook) will be included in the environmental justice analysis as relevant.



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 8140
 8141
 8142
 8143

Figure 3-229. Low-Income Populations in the Study Area

*The Columbia River Basin boundary is consistent with the affected environment for most resources analyzed. The broader boundary was used for the power generation and transmission, and air quality resources, consistent with Sections 3.7 and 3.8.

8144 **3.18.2.2 Identification of Minority Populations**

8145 This analysis applies the CEQ guidance (CEQ 1997) to identify minority populations.⁷ For
8146 purposes of the environmental justice analysis, minority populations are identified by
8147 comparing the minority population percentage in an affected area (i.e., census block group) to
8148 the minority population percentage in the associated state population (i.e., general population).
8149 Areas with a higher percentage of minority population than the statewide minority population
8150 percentage are classified as minority populations. For purposes of the analysis, “minority”
8151 includes individuals who list their racial status as a race other than White Alone and/or list their
8152 ethnicity as Hispanic or Latino. The statewide minority population percentage used for
8153 comparison is shown in Table 3-306, which also provides a breakdown of racial and ethnic
8154 population by state.

⁷ CEQ guidance includes the following threshold for identifying minority populations: “minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis” (CEQ 1997).

8155 **Table 3-306. Summary of Race and Ethnicity by States that Intersect Study Area^{1/}**

State	Total Population	% of Total Population ^{2/} White Alone	% of Total Population ^{2/} Total Minority Population ^{3/}	Race and Ethnicity				
				% of Total Population ^{2/} American Indian or Alaskan Native Alone	% of Total Population ^{2/} Asian or Pacific Islander Alone	% of Total Population ^{2/} Black or African American Alone	% of Total Population ^{2/} Hispanic or Latino	% of Total Population ^{2/} Two or More Races
California	38,654,206	38%	62%	0%	14%	6%	39%	3%
Idaho	1,635,483	83%	17%	1%	1%	1%	12%	2%
Montana	1,023,391	87%	13%	6%	1%	0%	3%	2%
Nevada	2,839,172	51%	49%	1%	8%	8%	28%	3%
Oregon	3,982,267	77%	23%	1%	4%	2%	12%	3%
Washington	7,073,146	70%	30%	1%	8%	3%	12%	4%
Wyoming	583,029	84%	16%	2%	1%	1%	10%	2%

8156 1/ A breakdown of race and ethnicity at the county level for counties within the study area can be found in Environmental Justice Appendix.

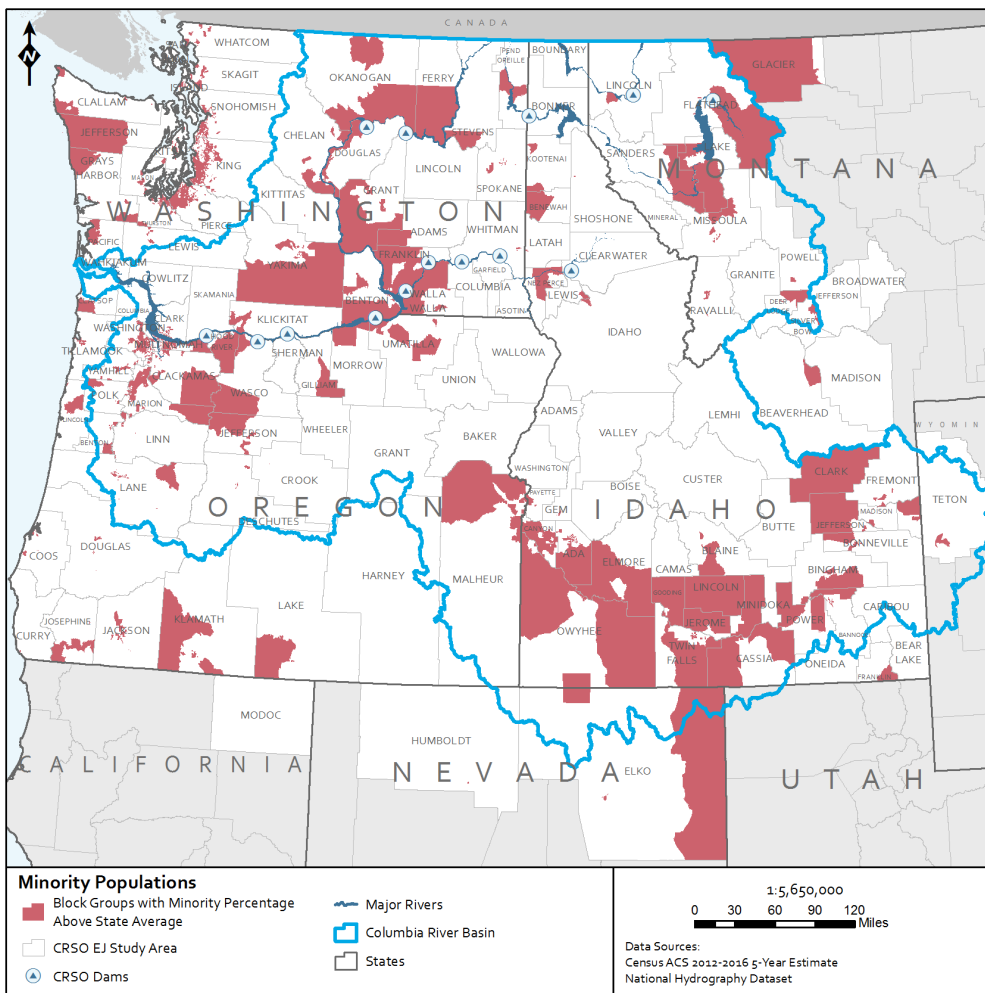
8157 2/ The U.S. Census distinguishes ethnicity as either “Hispanic or Latino” or “Not Hispanic or Latino.” Within these two ethnic groups, the Census reports racial
8158 identification (e.g., White Alone, American Indian or Alaskan Native Alone, Asian or Pacific Islander Alone Black or African American Alone, Two or More Races).
8159 For the purpose of this analysis, all people in the Hispanic or Latino ethnic group are counted as Hispanic or Latino, regardless of their race. For example, a
8160 person that is of Hispanic or Latino ethnicity that identifies as black or African American would not appear in the Black or African American category but rather
8161 in the Hispanic or Latino category.

8162 3/ For purposes of this analysis, minority population reflects all populations not identified as "Not Hispanic or Latino: White alone" in the ACS.

8163 Source: U.S. Census Bureau (2017b)

8164 The majority of residents in each state identify as White Alone, ranging from 51 to 87 percent
 8165 of statewide populations, with the exception of California in which only 38 percent of residents
 8166 identify as White Alone (not Hispanic or Latino). The Hispanic or Latino population represents
 8167 the second highest racial/ethnic group behind White Alone in all states except Montana in
 8168 which the second largest racial/ethnic group is American Indian or Alaskan Native Alone.

8169 Figure 3-230 illustrates census block groups within the 139-county study area that are identified
 8170 as minority populations based on the 2012–2016 ACS (Census 2017a). In the study area, 3,174
 8171 of 8,793 total census block groups (36 percent) have a minority population percentage in the
 8172 census block group that is greater than the statewide minority population percentage. These
 8173 “minority” census block groups had a combined population of over 5.2 million, comprising 39
 8174 percent of the study area population. A more detailed breakdown of minority populations by
 8175 county is provided in Appendix O, *Environmental Justice*.



8176
 8177 **Figure 3-230. Minority Populations in the Study Area**

8178 *The Columbia River Basin boundary is consistent with the affected environment for most resources analyzed. The
 8179 broader boundary was used for the power generation and transmission, and air quality resources, consistent with
 8180 Sections 3.7 and 3.8.

8181 **3.18.2.3 Identification of Indian Tribes**

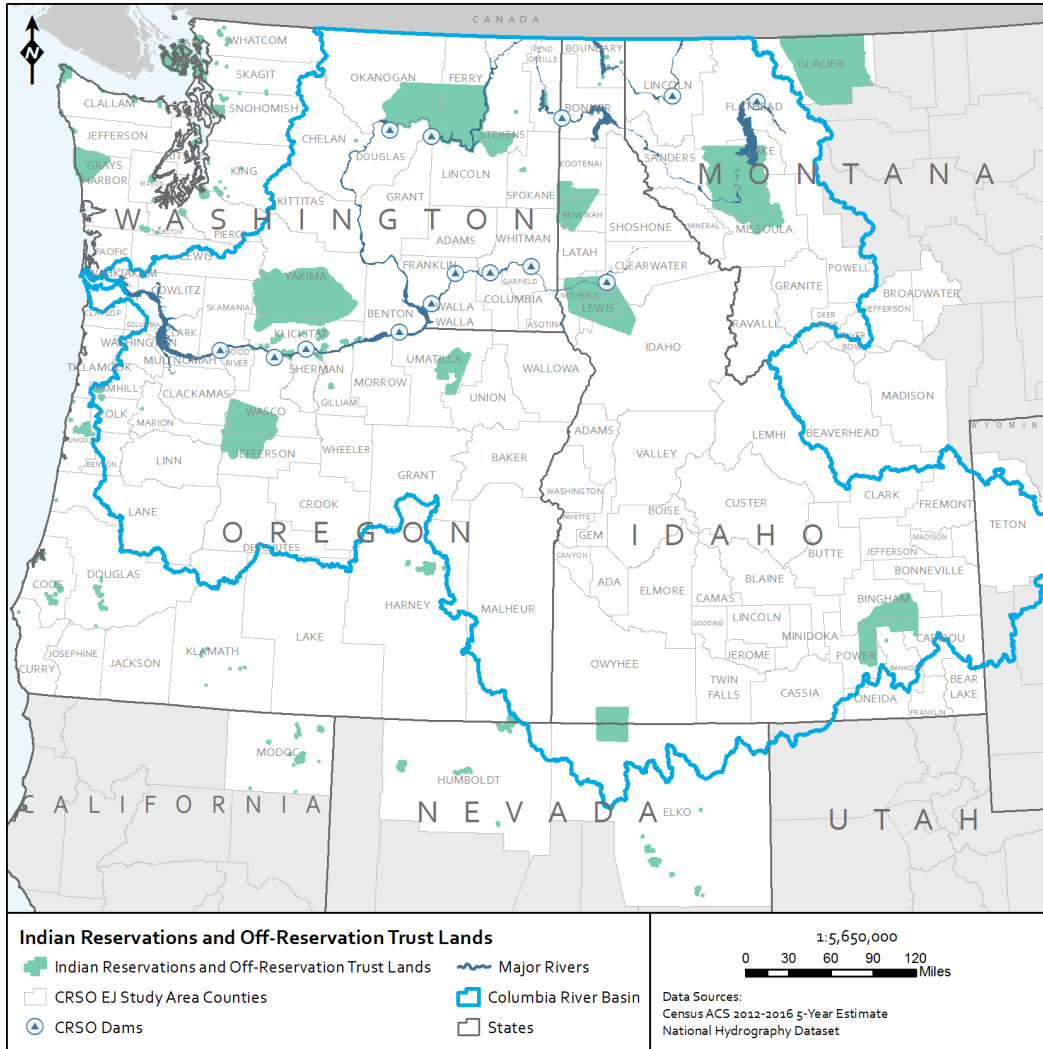
8182 Indian tribes in the Columbia River Basin rely on the Columbia River, its tributaries, and
8183 surrounding areas, for fishing, hunting, gathering, and conducting traditional and religious
8184 ceremonies. Tribal cultural and social values typically reflect a higher intensity and range of use
8185 of natural resources by tribal communities than the general population. Natural and cultural
8186 resources associated with the Columbia River Basin are of critical importance to Indian tribes in
8187 the region for subsistence, commerce, preservation of cultural traditions and history, religious
8188 practice, and self-determination as sovereign nations. Salmon and Pacific lamprey are, in
8189 particular, part of the spiritual and cultural identity of most of the Columbia River Basin's Indian
8190 tribes. These fish are among the traditional foods that are honored in many tribal ceremonies.
8191 A summary of the historical uses of the Columbia River Basin by Native Americans, as well as
8192 some of the factors that have led to current conditions, are discussed in Section 3.16 *Cultural*
8193 *Resources* and Section 3.17 *Indian Trust Assets, Tribal Perspectives and Tribal Interests* of this
8194 EIS. As discussed, the current areas that are identified as reservation lands or off-reservation
8195 lands held in trust for the Indian tribes are a small portion of the areas historically used by the
8196 Indian tribes. Figure 3-231 identifies current Indian reservation and off-reservation trust lands
8197 within the environmental justice study area.

8198 Demographic information for Indian tribes in the study area has been collected from the Census
8199 and is presented in Appendix O, *Environmental Justice*. These data include metrics typically
8200 used by researchers and in EPA's EJSCREEN to represent the "social vulnerability"
8201 characteristics of a disadvantaged population (EPA 2017). Census information presented in
8202 Appendix O demonstrates that, in most cases, the populations residing on reservation lands (as
8203 well as off-reservation trust lands) in the study area have higher poverty rates, higher
8204 unemployment, and lower household and per capita incomes than the averages for the states
8205 where they are located.

8206 The current lack of prosperity on Indian reservations is due to numerous factors. Miller (2012)
8207 provides context for the situation on Indian reservations throughout the United States, stressing
8208 both the current lack of vibrant functioning economies on Indian reservations, as well as the
8209 importance of developing functioning economies in Indian communities to create economic
8210 stability which, in turn, enables community building and preservation of culture. A 2012 report
8211 found that among tribal populations on and near Washington's tribal reservations, each
8212 employed person supported more than three others who were not employed, versus a ratio of
8213 one to one in Washington generally (Taylor 2012). The labor participation rate was 39 percent
8214 among tribal populations on or near reservations in Washington compared with 74 percent
8215 across Washington State in general (Taylor 2012). Another report highlights the circumstances of
8216 the Indian tribes located in the lower Snake River region (Nez Perce, Yakama, Umatilla, Warm
8217 Springs, and Shoshone-Bannock Tribes), but is broadly applicable in the Columbia River Basin:

8218 Viewed from the perspective of objective statistics, the peoples of the study tribes must
 8219 today cope with overwhelming levels of poverty, unemployment that is between three
 8220 and thirteen times higher than for the region’s non-Indians, and rates of death that are
 8221 from twenty percent higher to more than twice the death rate for residents of
 8222 Washington, Oregon and Idaho as a whole (Meyer Resources 1999).

8223 The report goes on to describe principal causes of the present impoverishment of the study
 8224 tribes include the loss of salmon and the loss of tribal lands (Meyer Resources 1999).



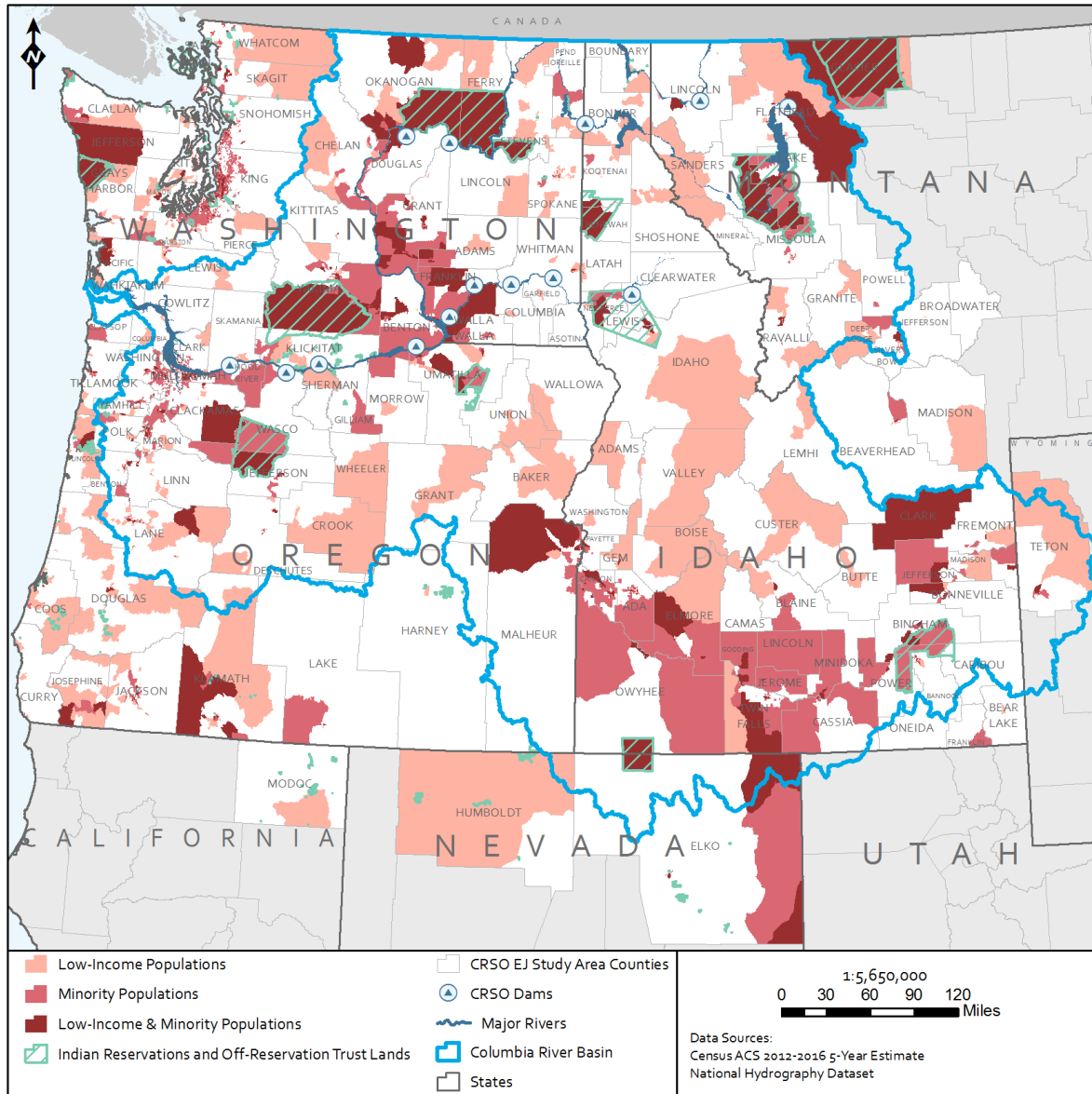
8225
 8226 **Figure 3-231. Indian Reservations and Off-Reservation Trust Lands within CRSO Regions**
 8227 *The Columbia River Basin boundary is consistent with the affected environment for most resources analyzed. The
 8228 broader boundary was used for the power generation and transmission, and air quality resources, consistent with
 8229 Sections 3.7 and 3.8.

8230 Note: Per Census, “[t]he boundaries for federally recognized American Indian reservations and off-reservation
 8231 trust lands are as of January 1, 2017, as reported by the federally recognized tribal governments through the
 8232 Census Bureau’s Boundary and Annexation Survey” (Census 2017b). The Census layer is incomplete, missing some
 8233 off-reservation trust lands, in-lieu fishing sites, and fishing access sites.

8234 Source: Census (2017b)

8235 **3.18.2.4 Summary of Populations Considered in the Environmental Justice Analysis**

8236 Figure 3-232 provides a geographic representation of the locations of minority populations,
 8237 low-income populations, and Indian tribes within the study area. This includes 4,169 (out of a
 8238 total of 8,793) census block groups identified as minority, low-income, or both, as well as tribal
 8239 lands within the study area. Of the census block groups identified as minority populations or
 8240 low-income populations, 1,225 (nearly 30 percent) are classified as both low-income and
 8241 minority populations.



8242 **Figure 3-232. Minority and Low-Income Populations, Indian Reservations, and Off-**
 8243 **Reservation Trust Lands in the Study Area**

8245 *The Columbia River Basin boundary is consistent with the affected environment for most resources analyzed. The
 8246 broader boundary was used for the power generation and transmission, and air quality resources, consistent with
 8247 Sections 3.7 and 3.8.

8248 **3.18.3 Environmental Consequences**

8249 The environmental justice analysis evaluates whether there would be disproportionately high
8250 and adverse human health or environmental effects on minority populations, low-income
8251 populations, or Indian tribes resulting from changes to resources under the MOs in accordance
8252 with E.O. 12898 and the associated guidance published by the CEQ in 1997 (CEQ 1997). While
8253 tables 6-40 and 6-41 in Chapter 6 are not duplicated within this environmental justice section,
8254 those tables provide summaries of direct, indirect and reasonably foreseeable future actions
8255 relevant to environmental justice populations which are incorporated into the analysis in this
8256 section.

8257 **3.18.3.1 Resources Not Analyzed Further in this Section**

8258 Several resources addressed in the EIS are not analyzed further in the environmental justice
8259 analysis because: the resource would not be affected or would have minimal effects across
8260 alternatives; it is readily apparent that resource effects would not be likely to
8261 disproportionately affect low-income populations, minority populations, or Indian tribes; or
8262 because the resource effects are subsumed in other resource evaluations. Effects to these
8263 resources are summarized below.

8264 **Hydrology and hydraulics, and river mechanics.** Effects to these resources are evaluated
8265 through other resource effects (in particular, Section 3.5, *Aquatic Habitat, Aquatic*
8266 *Invertebrates, and Fish*; Section 3.6, *Vegetation, Wildlife, Wetlands, and Floodplains*; and
8267 Section 3.16, *Cultural Resources*).

8268 **Water quality.** The MOs may affect water quality, which could affect public health conditions if
8269 nutrient loading, water clarity, or the level of contaminants suspended in rivers were
8270 affected. Some minority populations, low-income populations, or Indian tribes may have
8271 different or more intense use of river resources for drinking, fishing, recreating, or
8272 subsistence practices than the general population. Populations who rely on subsistence
8273 fishing in Lake Roosevelt could be negatively impacted if the bioaccumulation of heavy
8274 metals increase under MO4; this is discussed further in the context of fish resources below.
8275 Adverse effects to drinking water have not been identified in the Water Quality analysis.⁸
8276 Effects related to water quality changes were not analyzed separately in this environmental
8277 justice section because those effects are captured in the evaluation of effects to other
8278 resources, namely, Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*; Section
8279 3.6, *Vegetation, Wildlife, Wetlands, and Floodplains*; Section 3.11, *Recreation*; Section 3.16,
8280 *Cultural Resources*; and Section 3.17, *Tribal Trust Assets, Tribal Perspectives, and Tribal*
8281 *Interests*.

8282 **Vegetation, wildlife, wetlands, and floodplains.** In general, the analyses of effects to
8283 vegetation, wildlife, wetlands, and floodplains. identified negligible to minor effects to these

⁸ The co-lead agencies do not have jurisdiction over drinking water quality, and do not guarantee the quality of water available for consumptive uses. Due to the multiple processes that drinking water undergoes during treatment, the variability in each user's source of drinking water and the lack of jurisdiction over the resource, the co-lead agencies did not perform analyses of drinking water quality.

8284 resources across most MOs. Potential adverse effects on resources are identified in Region
8285 C under MO3. Effects include changes to the types of vegetation and wildlife supported
8286 along the shoreline of reservoirs as water levels fluctuate under the MOs. These changes
8287 have the potential to adversely affect plants used for ceremonial and subsistence gathering
8288 activities by tribal populations that may occur in affected areas. Under MO3, in the short-
8289 term immediately following breach, subsistence gathering and traditional hunting and
8290 trapping activities may be affected by changes in resource availability. Upon
8291 reestablishment of vegetation communities, the target species are expected to return and
8292 be available for traditional hunting and trapping activities. Therefore, effects are anticipated
8293 to be minor with no disproportionately high and adverse effects on minority, low-income,
8294 or tribal populations.

8295 **Air quality.** The MOs have the potential to adversely affect air quality and human health
8296 conditions, particularly under alternatives that could result in a reduction in hydropower
8297 and potential increase in fossil fuel use, which may occur under MO3 and MO4. If fossil fuel-
8298 based power generation increases, air pollutant emissions would increase. To the extent
8299 that these increases would occur near low-income, minority, or tribal populations, adverse
8300 effects to air quality in those communities could result. However, there are a number of
8301 uncertainties surrounding the likelihood, volume, and specific location of future emissions
8302 that render making a determination of effects to specific communities highly speculative at
8303 this time.

8304 In particular, given recent and emerging regulatory and policy initiatives in the
8305 Northwest, the extent and likelihood of increased regional fossil fuel generation is
8306 uncertain, as is the location of any new sources of fossil fuel generation that could be
8307 required under the MOs.

8308 The analyses of effects to air quality also identified minor to moderate short-term
8309 effects related to construction projects; however, given the short-term nature of these
8310 projects and the potential for best practices in construction to avoid adverse effects, the
8311 likelihood of disproportionately high and adverse effects are not expected on minority
8312 populations, low-income populations, or Indian tribes. In addition, anticipated increased
8313 air pollutant emissions associated with shifts in the mode of transporting goods under
8314 MO3 would be long term. To the extent that transportation routes and hubs are located
8315 in areas where minority populations, low-income populations, or Indian tribes are
8316 located, these populations may be affected. However, these effects would likely be
8317 small relative to total transportation-related air pollutant emissions under the No Action
8318 Alternative.

8319 **Flood risk management.** The MOs were analyzed to determine the potential to affect flood risk
8320 in the region. However, the flood risk analysis in Section 3.9 of this EIS does not anticipate
8321 changes to flood risk from any of the MOs.

8322 **Visual resources.** Visual effects associated with construction or modification of facilities are
8323 anticipated under various MOs. Tribal members engaging in traditional cultural practices or

8324 visiting sites may have their visual experience effected by new infrastructure associated
8325 with MOs. However, the analyses of effects to visual resources identified negligible to minor
8326 effects to these resources across most MOs. Negligible to minor adverse effects on
8327 resources were identified in Region C under MO3. In particular, local residents and visitors
8328 would experience aesthetic changes due to losses of lake-like characteristics and a return to
8329 free-flowing riverine characteristics under MO3 in the vicinity of reservoirs in the lower
8330 Snake River. However, these minor to negligible adverse effects do not appear likely to
8331 disproportionately affect minority populations, low-income populations, or Indian tribes.
8332 Indeed, certain Indian tribes in the area, such as the Nez Perce Tribe, support breaching the
8333 four lower Snake River dams.

8334 **Noise.** The primary noise effects are expected under MO3 related to the breaching of earthen
8335 embankments and other major structural changes to the four lower Snake River projects.
8336 These short-term effects would occur in isolated areas without residences immediately
8337 nearby. While other structural measures would result in some noise effects, these are
8338 expected to be negligible to minor. The proposed MO3 operational and structural measures
8339 at Dworshak, which is within the Nez Perce Reservation, are likely to create noise effects
8340 that are similar to the NAA and would be negligible. These negligible to minor effects do not
8341 appear likely to disproportionately affect minority populations, low-income populations, or
8342 Indian tribes.

8343 **3.18.3.2 Resources Analyzed Further in this Section**

8344 For the following resources, the environmental justice analysis compares effects to the general
8345 population and effects to minority populations, low-income populations, and Indian tribes by
8346 alternative and by region and determines if disproportionately high and adverse effects may
8347 occur to EJ populations.

8348 **Fish.** Commercial, ceremonial, and subsistence fishing activity occurs in various locations on the
8349 mainstem Columbia and Snake Rivers and in tributaries throughout the study area. The MOs
8350 have the potential to affect the availability of fish for low-income populations, minority
8351 populations and Indian tribes participating in these activities.

8352 The river mechanics analysis indicates minor increases in the mobility of bed material in
8353 Lake Roosevelt under MO4. If contaminated slag is present in the mobilized bed
8354 material, this could create additional toxicity in fish and other aquatic organisms.
8355 However, the change in potential toxicity is unknown. Reservoir drawdowns of longer
8356 duration under MO4, increase the exposure of shorelines. Increased exposure has the
8357 potential to increase mercury methylation rates, which could lead to greater buildup of
8358 mercury quantities in aquatic organisms (i.e. bioaccumulation) (Willacker 2016).
8359 Populations who rely on subsistence fishing in Lake Roosevelt could be negatively
8360 impacted if the bioaccumulation of heavy metals increases.

8361 **Power generation and transmission.** The MOs have the potential to place upward pressure on
8362 electricity rates. The base case methodology and cost sensitivities analysis are described in

8363 the Power Generation and Transmission section of this chapter under the environmental
8364 consequences sub-section, 3.7.3.1. The typical median household income in low-income
8365 populations, minority populations, and Indian tribes in the study area is \$39,000.⁹ Low-
8366 income households typically spend a larger portion of their income on home energy costs
8367 (e.g., electricity, natural gas, and other home heating fuels) than other households spend
8368 (DOE 2018). These households may also have a more difficult time adapting to a higher cost
8369 of living if annual electricity bills increase.¹⁰ Using 6 percent as a threshold of affordability
8370 for energy, low-income households in low-income populations, minority populations, or
8371 Indian tribes (or both) in the study area could afford annual energy costs (including
8372 electricity, gas and other fuel expenditures) of approximately \$2,340.¹¹ Anticipated rate
8373 changes for each county are illustrated graphically in the Section 3.7, *Power and*
8374 *Transmission*. Discussion of impacts of alternatives on transmission services and energy
8375 markets and the impacts on reliability is also included in Section 3.7, *Power and*
8376 *Transmission*. The potential effects of the MOs on transmission rate pressure are captured
8377 in the analysis of residential, commercial, and industrial retail rates. Upward rate pressure
8378 on commercial and industrial rates for end-users are expected to be small under MO1 and
8379 MO2. While the upward rate pressure is greater under MO3 and MO4, the potential effects
8380 on the cost of electricity as a percentage of the total costs of production of goods and
8381 services in the region would be small. Therefore, whether the potential extent to which
8382 those costs could be passed on to consumers is uncertain. Given this, if there are any effects
8383 of the MOs on the price of goods and services in the region, which is uncertain, the effects
8384 to regional consumers—including low-income populations, minority populations or Indian
8385 tribes—would be very slight.

8386 Separately, to the extent that the volume of power sales revenue and generation at
8387 Grand Coulee Dam would change under the MOs, annual payments to the Confederated
8388 Tribes of the Colville Reservation, mandated by the Grand Coulee Dam Settlement
8389 Agreement Act of 1994, could be affected.

8390 **Navigation and transportation.** Changes to in-river and reservoir conditions under the MOs
8391 could affect the availability of ports for commercial navigation activities (including
8392 commercial shipping barges, cruise ships, and ferries). Costs of shipping goods in the region

⁹ Low-income and minority populations are identified based on census block group, as described in Section 3.15.2. Indian tribes are described geographically using current reservation and off-reservation trust lands. Native American people are often included in both the minority and Indian tribal populations.

¹⁰ Based on the Low-Income Energy Affordability Data (LEAD) Tool, developed by DOE's Office of Energy Efficiency & Renewable Energy, the current average household energy cost in the study area (including electricity, natural gas, and other home heating fuels) ranges from \$384 to \$3,492, depending on the census tract. Energy burden is defined as the average annual housing energy costs divided by the average annual household income. For households with incomes higher than the poverty level these costs represent an energy burden of 1 to 4 percent. In contrast, these costs represent an energy burden of 5 to 48 percent (depending on the census tract) for households in the study area with incomes less than the Federal poverty level (DOE 2016).

¹¹ Some researchers suggest home energy bills should be considered unaffordable when they exceed 6 percent of a household's annual gross income (Fisher Sheehan & Colton 2015). This is based on the assumption that a household can afford to spend about 30 percent of its income on shelter costs, of which about 20 percent are used for energy bills (or 6 percent of total income).

8393 may increase under some MOs. If increases in transportation costs for agricultural products
8394 grown in the area result in changes to operations, farming employment opportunities for
8395 low-income or minority farmworkers (or both) in the study area could be affected.
8396 Inchelium-Gifford Ferry operations on Lake Roosevelt could also be affected by operational
8397 measures in some MOs that would result in additional reservoir fluctuations, including
8398 earlier and/or deeper drawdowns in some years. This ferry is operated by the Confederated
8399 Tribes of the Colville Reservation and primarily serves the tribal population.

8400 **Water supply.** The MOs have the potential to affect access to water sources, as well as the
8401 costs to supply water. Effects are focused on a need to extend pumps under MO4 to allow
8402 for continued water supply, and the potential loss of irrigation under MO3 because the
8403 pumps that supply this water would no longer be operational once the dams were breached
8404 and the nearby groundwater elevations could be adversely impacted. If the MOs affect
8405 drinking water or agricultural water sources for minority populations, low-income
8406 populations, or Indian tribes, this could affect the cost of living in an area as well as the
8407 availability of employment opportunities.

8408 **Recreation.** Changes in river and reservoir conditions under the MOs could affect the quality
8409 and availability of recreational opportunities and associated employment opportunities for
8410 minority populations, low-income populations, and Indian tribes in the study area.
8411 However, the analyses of effects to recreation identified negligible to minor effects to these
8412 resources across most MOs. Adverse effects on resources are identified in Region C under
8413 MO3. In addition, localized adverse effects for recreational fishing may exist along the
8414 Clearwater River in Region C in August and September under MO1.

8415 **Cultural resources.** The MOs have the potential to affect cultural resources (including
8416 archaeological resources, TCPs, historic built resources, and sacred sites) as a result of
8417 changes in reservoir elevations or construction activities. Natural and cultural resources
8418 associated with the Columbia River Basin are of critical importance to Indian tribes in the
8419 region for subsistence, commerce, preservation of cultural traditions and history, religious
8420 practice, and self-determination as sovereign nations. Indian tribes in the Columbia River
8421 Basin continue to rely on the river, its tributaries, and surrounding areas for fishing, hunting,
8422 gathering, and conducting traditional and religious ceremonies. In particular, fish are an
8423 important component in the health of tribal members in the Northwest. To date, hundreds
8424 of Traditional Cultural Properties (TCPs), multiple built historic resources, and over 4,500
8425 archaeological sites have been recorded in the area of potential effects for the 14 CRS
8426 projects (FCRPS 2018). Two sacred sites were identified in the study area: Bear Paw Rock
8427 and Kettle Falls (please see Section 3.16.2.7 for additional information). As discussed in
8428 Section 3.16, Cultural Resources, ongoing effects of inundation and reservoir fluctuation
8429 would continue to have major adverse effects on TCPs under the No Action Alternative.
8430 Implementation of the MOs could negatively affect cultural resources through increasing
8431 exposure and erosion associated with increased reservoir level fluctuations. In addition to
8432 increasing the potential for damage and decay due to erosion, increased exposure can
8433 create the potential for effects associated with public access including looting, vandalism,

8434 creation of trails, and unauthorized activities. Indian Trust Assets are analyzed in Section
8435 3.17 of this EIS.

8436 **3.18.3.3 Effects Assessment Methodology**

8437 In order to determine whether environmental effects are disproportionately high and adverse
8438 on minority populations, low-income populations, or Indian tribes, CEQ in its *“Environmental*
8439 *Justice, Guidance Under the National Environmental Policy Act”* guides agencies to consider the
8440 following three factors:

8441 Whether there would be a “significant” (as defined by NEPA) ecological, cultural, human health,
8442 economic, or social impact that would adversely affect a minority population, low-income
8443 population, or Indian tribe.

8444 Whether “significant” (as defined by NEPA) effects on a minority population, low-income
8445 population, or Indian tribe may appreciably exceed those experienced by the general
8446 population.

8447 Whether cumulative or multiple adverse exposures from environmental hazards would affect a
8448 minority population, low-income population, or Indian tribe (CEQ 1997).

8449 To evaluate these factors, the analysis followed these general steps:

8450 Identify populations that are considered to be environmental justice populations (presented in
8451 Section 3.15.2.4).

8452 Identify whether the MOs would result in direct, indirect or cumulative (i.e. past, present or
8453 reasonably foreseeable future as described in Chapter 6) resource effects to minority
8454 populations, low-income populations, or Indian tribes.

8455 Assess and describe the nature and relative intensity (e.g., magnitude) of resource effects that
8456 would be borne by the general population and compare those effects to the effects to
8457 minority populations, low-income populations, or Indian tribes. Consider relevant factors
8458 that may amplify effects to minority populations, low-income populations, or Indian tribes.

8459 Summarize moderate and major effects by each MO and consider the effect of incorporating
8460 mitigation identified for each MO.

8461 For each alternative, identify if there are any disproportionately high and adverse effects on
8462 minority populations, low-income populations, or Indian tribes.

8463 This section presents the likely EJ finding for each MO and includes consideration of direct and
8464 indirect effects in Chapter 3, climate effects described in Chapter 4, mitigation described in
8465 Chapter 5, and cumulative effects described in Chapter 6. Chapters 7 and 8 provide the EJ
8466 finding for the Preferred Alternative.

8467 While beneficial environmental justice effects to resources may occur within MOs, those
8468 beneficial effects are generally not discussed in this analysis, except when beneficial effects
8469 could minimize adverse effects.

8470 **3.18.3.4 No Action Alternative**

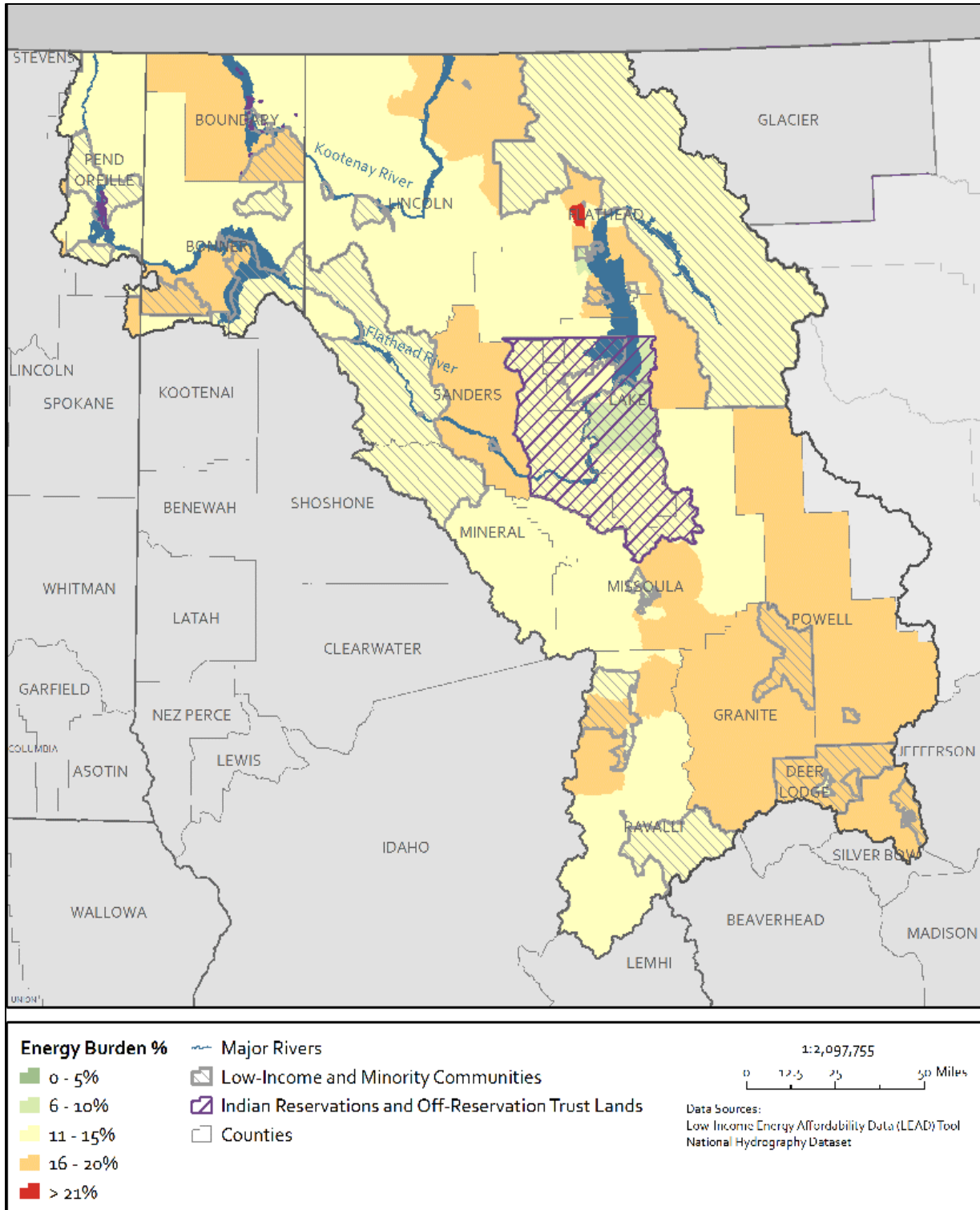
8471 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

8472 Approximately 40 percent of the census block groups in Region A are classified as low-income
8473 or minority or both. Low-income and minority block groups are located near Albeni Falls and
8474 Hungry Horse Dams. There are also a number of Indian tribes with reservation lands and off-
8475 reservation trust lands in Region A, including the Kootenai Tribe of Idaho, the Confederated
8476 Salish and Kootenai Tribes, and the Kalispel Tribe of Indians. The following resource effects
8477 would occur in Region A under the No Action Alternative, affecting minority populations, low-
8478 income populations, or Indian tribes:

8479 **Fish.** This EIS assumes that ceremonial and subsistence fishing activities for Indian tribes as well
8480 as other subsistence fishers, including minority and low-income populations, would be
8481 relatively consistent with current levels under the No Action Alternative. The Kootenai Tribe
8482 of Idaho relies heavily on subsistence fishing; the Kootenai River itself is part of the Tribe's
8483 identity and a number of historical fishing camp locations occur along the River. Fish are
8484 also an important component in the health of tribal members. Research indicates that loss
8485 of traditional food sources may put indigenous people at greater risk for a variety of diet-
8486 related illnesses. According to a 1994 CRITFC study, fish consumption is higher among the
8487 four Lower River treaty tribes than the general public. Some low-income and minority
8488 populations may participate in subsistence fishing throughout the region.

8489 **Power generation and transmission.** The average annual cost of electricity per household in
8490 Region A under the No Action Alternative would range from approximately \$750 to \$1,500,
8491 depending on the county. Figure 3-233 illustrates the energy burden for households below
8492 the poverty level in low-income communities, minority communities, as well as on Indian
8493 tribal lands in Region A. As shown, the current total energy burden for these areas ranges
8494 from 9 to 22 percent for households.¹² In contrast, households above the poverty level have
8495 energy burdens that range from 2 to 4 percent in Region A (DOE 2016). As noted above,
8496 energy burdens above 6 percent can be considered unaffordable. As such, low-income
8497 communities, minority communities, and Indian tribes, and particularly low-income
8498 households in these communities, already experience potentially unaffordable energy
8499 burdens under the No Action Alternative in Region A. Any upward rate pressure in this
8500 region could impact low-income households for whom energy costs are a larger percent of
8501 their income. In some cases, these low-income households are also minority, tribal, or both,
8502 but these impacts would occur across the region at levels that would not be considered
8503 disproportionately high and adverse.

¹² LEAD is reported at the Census tract level, which is a larger unit than the census block groups used to identify these populations. Census tract level data is used to characterize these populations.



8504
 8505
 8506

Figure 3-233. Percent of Household Income Spent on Energy (Energy Burden) for Households Below Poverty Level – Region A

8507 **Navigation and transportation.** Commercial navigation, cruise ships, and ferries do not occur in
8508 Region A. This would not change under the No Action Alternative. Navigation and
8509 transportation is not discussed further in Region A for any alternative.

8510 **Water supply.** Municipal and industrial and irrigation would not be affected in Region A under
8511 any alternative and is not discussed further in Region A for any alternative.

8512 **Recreation.** As described in the Recreation section, in Region A, total recreational visitation
8513 under the No Action Alternative is anticipated to be approximately 1.5 million visits
8514 annually, primarily associated with visitation at Hungry Horse, Libby and Albeni Falls/Lake
8515 Pend Oreille. There are a number of minority, low-income, or Tribal populations in Region A
8516 that may engage in recreational activities and reside in proximity to the affected recreation
8517 sites, including the Confederated Salish and the Kootenai Tribes of the Flathead, Kalispel
8518 Tribe, Coeur D'Alene Tribe, and the Blackfeet Tribe of the Blackfeet Indian Reservation of
8519 Montana. Visitation to recreation areas also supports employment and spending in local
8520 areas around the recreation sites. The average annual regional economic contribution of
8521 recreational activity in terms of jobs and output is described in the Recreation section.

8522 **Cultural resources.** As detailed in Section 3.16.2.6., numerous traditional cultural properties are
8523 present in the vicinity of projects in Region A. No traditional cultural properties were
8524 identified at the Libby Project due to the co-lead agencies having no geospatial data. In
8525 addition, Bear Paw Rock has been identified as a sacred site affected by operations of
8526 Albeni Falls. Traditional cultural properties and the Bear Paw Rock sacred site would
8527 continue to be adversely affected under the No Action Alternative due to ongoing
8528 operations and maintenance of the Columbia River System.

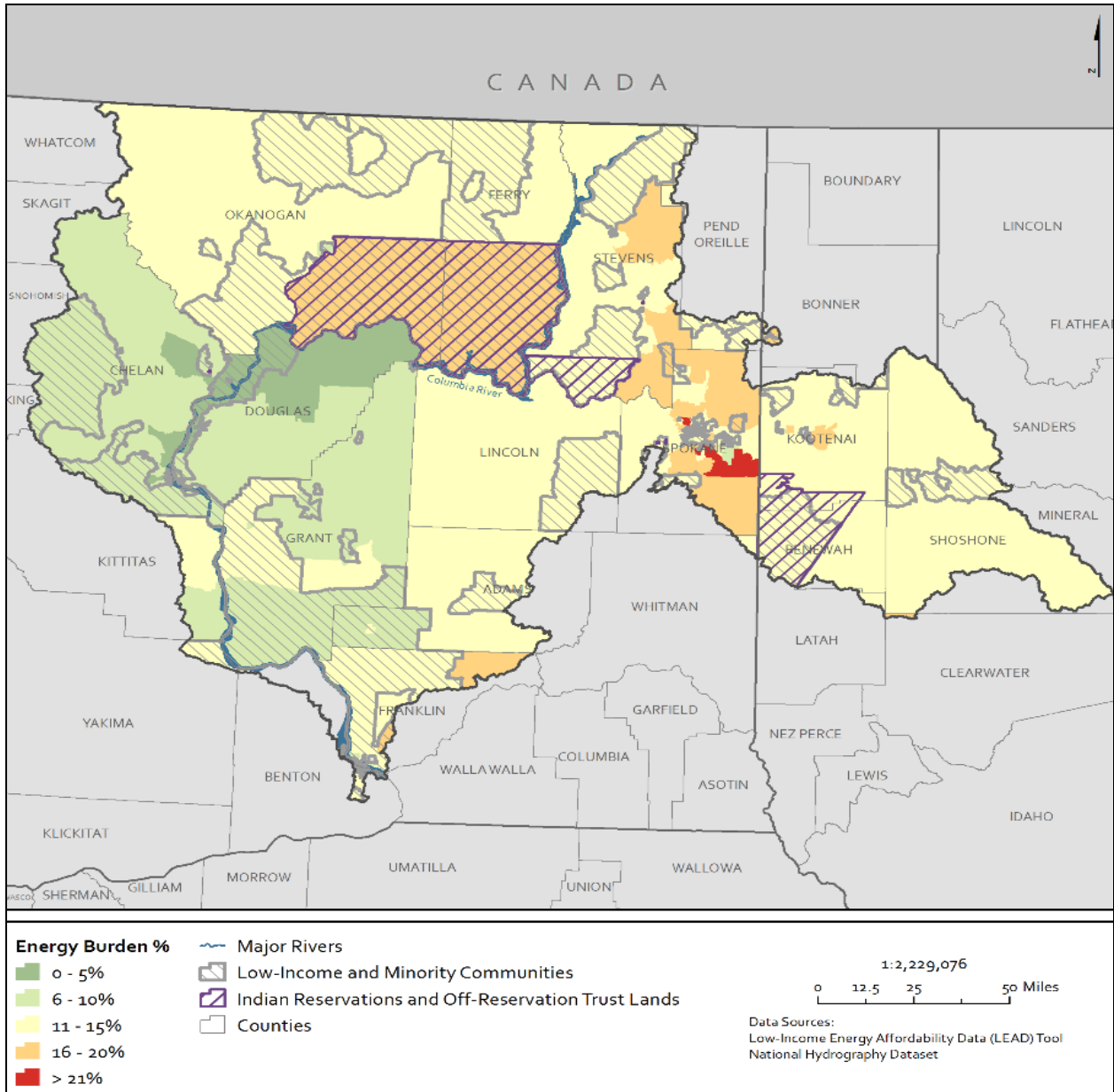
8529 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

8530 Approximately 45 percent of census block groups in Region B are classified as low-income
8531 populations, minority populations, or both. Low-income and minority block groups are located
8532 near the Grand Coulee and Chief Joseph Projects. There are also a number of Indian tribes with
8533 reservation lands and off-reservation trust lands in Region B, including the Confederated Tribes
8534 of the Colville Reservation (CTCR), the Spokane Tribe of Indians, and the Coeur d'Alene Tribe. A
8535 variety of ongoing activities would occur in Region B under the No Action Alternative that have
8536 the potential to affect minority populations, low-income populations, or Indian tribes. These
8537 include the following:

8538 **Fish.** A recreational fishery for Okanogan sockeye occurs in Region B. Kokanee, redband
8539 rainbow trout, white sturgeon, and burbot are important resources to the Indian tribes in
8540 Region B. Also rainbow trout are raised for release in tribal and recreational fisheries. Wild
8541 anadromous fish can access the Wenatchee, Entiat, and Methow watersheds in the upper
8542 Columbia River and tribes have been working to restore Pacific lamprey populations. This
8543 EIS assumes that ceremonial and subsistence fishing activities for Indian tribes as well as
8544 other subsistence fishers, including minority and low-income populations, would be
8545 relatively consistent with current levels under the No Action Alternative. Fish are also an
8546 important component in the health of tribal members. Research indicates that loss of
8547 traditional food sources may put indigenous people at greater risk for a variety of diet-

8548 related illnesses. According to a 1994 CRITFC study, fish consumption is higher among the
8549 four Lower River treaty tribes than the general public. Some low-income and minority
8550 populations may participate in subsistence fishing throughout the region.

8551 **Power generation and transmission.** The average annual cost of electricity per household in
8552 Region B under the No Action Alternative would range from \$310 to \$1,100 depending on
8553 the county. Figure 3-234 illustrates the energy burden for households below the poverty
8554 level in low-income communities, minority communities, as well as on Indian tribal lands in
8555 Region B. As shown, the current total energy burden for these areas ranges from 5 to 27
8556 percent for households. In contrast, households above the poverty level have energy
8557 burdens that range from 1 to 4 percent Region B (DOE 2016). As noted above, energy
8558 burdens above 6 percent can be considered unaffordable. As such, low-income
8559 communities, minority communities, and Indian tribes, and particularly low-income
8560 households in these communities, already experience potentially unaffordable energy
8561 burdens under the No Action Alternative in Region B. Any upward rate pressure in this
8562 region could impact low-income households, for whom energy costs are a larger percent of
8563 their income, but these impacts would occur across the region at levels that would not be
8564 considered disproportionately high and adverse. In some cases, these low-income
8565 households are also minority, tribal or both. The CTCR also receive annual payments under
8566 the Grand Coulee Settlement Agreement based on Bonneville power sales revenue and
8567 generation at Grand Coulee Dam, which is anticipated to continue under the No Action
8568 Alternative. The Spokane Tribe of Indians will also begin to receive annual payments in 2021
8569 which would continue under the No Action Alternative.



8570
 8571 **Figure 3-234. Percent of Household Income Spent on Energy (Energy Burden) for Households**
 8572 **Below Poverty Level – Region B**

8573 **Navigation and transportation.** The Inchelium-Gifford Ferry is operated by the CTRC, and
 8574 provides commuters, schoolchildren, tourists, and others with transportation for daily
 8575 activities including commuting to work, accessing health care, and participating in
 8576 educational activities. Under the No Action Alternative, reservoir elevations would be
 8577 expected to allow ferry operations throughout the year in typical years, but would be
 8578 unable to operate for approximately 27 days per year in wet years because the reservoir is
 8579 drawn down to accommodate flood waters below 1,229 feet to make space available in the

8580 reservoir for flood risk management (Section 3.10, *Navigation and Transportation*).¹³ When
8581 the ferry is not in service, the next nearest Columbia River crossing is approximately 34
8582 miles to the north on WA20/US395 and WA25/US395.

8583 **Water supply.** Municipal and industrial and irrigation would not be affected in Region B under
8584 any alternative and is not discussed further in Region B for any alternative.

8585 **Recreation.** As described in the Recreation section, in Region B, total recreational visitation
8586 under the No Action Alternative is anticipated to be around 2.0 million visits annually on
8587 average, primarily associated with visitation near Grand Coulee Dam (Lake Roosevelt) and
8588 Chief Joseph Dam (Lake Rufus Woods). There are a number of minority, low-income, or
8589 Tribal populations in Region B that may engage in recreation and reside in proximity to the
8590 affected recreation sites, including the Confederated Tribes of the Colville Reservation and
8591 the Spokane Tribe of Indians. Visitation to recreation areas also supports employment and
8592 spending in local areas around the recreation sites. The average annual regional economic
8593 contribution of recreational activity in terms of jobs and output is described in the
8594 Recreation section.

8595 **Cultural resources.** As detailed in Section 3.16.2.6., numerous traditional cultural properties are
8596 present in the vicinity of projects in Region B. In addition, Kettle Falls has been identified as
8597 a sacred site affected by operations of Grand Coulee. Traditional cultural properties and the
8598 Kettle Falls sacred site would continue to be adversely affected under the No Action
8599 Alternative due to ongoing operations and maintenance of the Columbia River System.

8600 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
8601 **HARBOR DAMS**

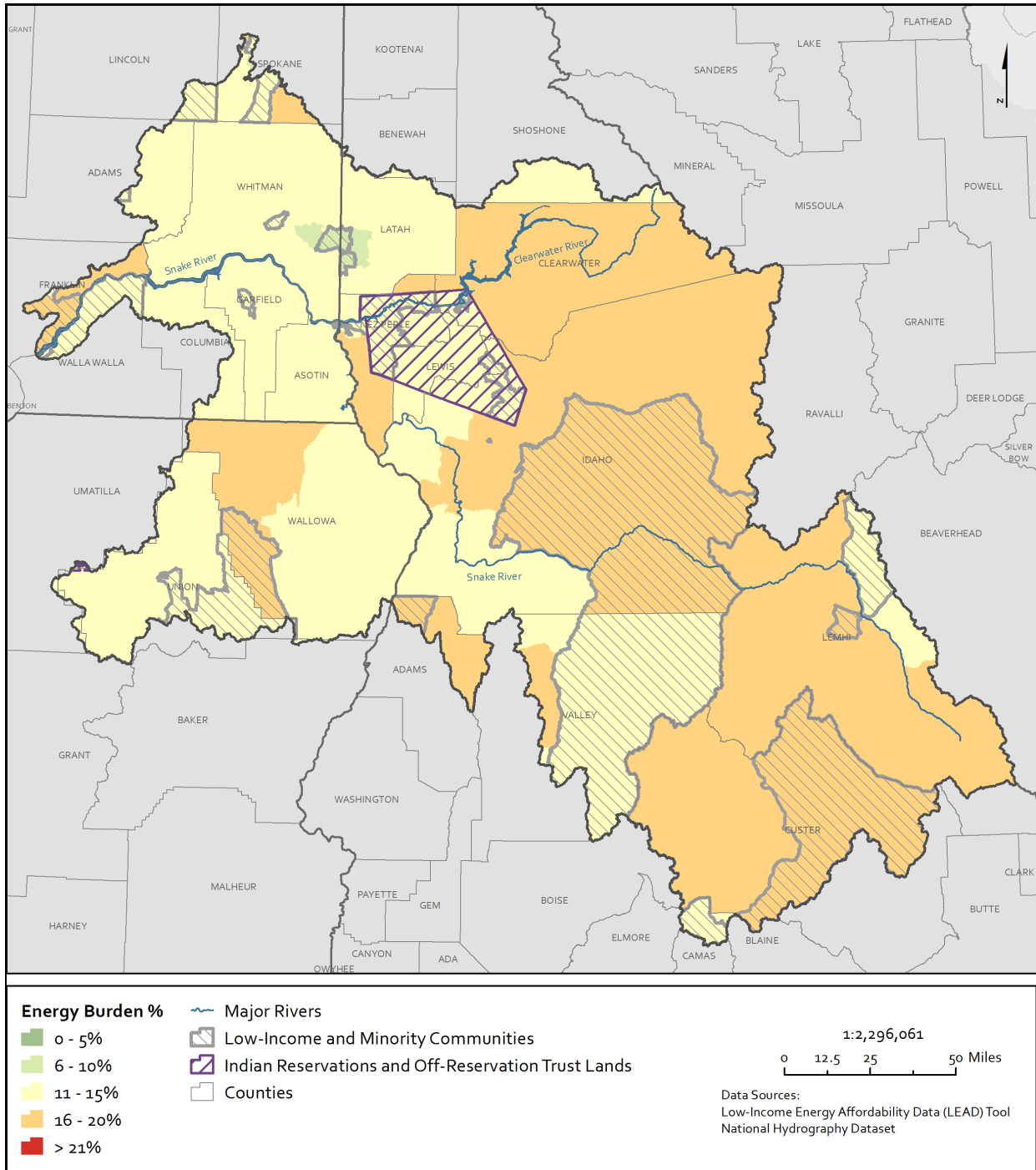
8602 Approximately one-third of the census block groups in Region C are classified as low-income or
8603 minority or both. Low-income and minority census block groups are located near the Ice
8604 Harbor, Lower Monumental, and Dworshak Projects. The Nez Perce Tribe has reservation and
8605 off-reservation trust lands in Region C, including an area overlapping with Dworshak. A variety
8606 of ongoing activities would occur in Region C under the No Action Alternative that have the
8607 potential to affect minority populations, low-income populations, or Indian tribes. These
8608 include the following:

8609 **Fish.** Under the No Action Alternative, ceremonial and subsistence fishing activity is assumed to
8610 be relatively consistent with current levels. Ceremonial and subsistence fishing, particularly
8611 for salmon, steelhead, lamprey, and white sturgeon, is an important cultural, economic, and
8612 spiritual practice for Indian tribes from the Pacific Coast to the Puget Sound and even the
8613 Inland Northwest (PFMC 1999) Salmon is considered vital to the Nez Perce way of life and
8614 future generations (Nez Perce Tribe DFRM 2018); the Shoshone-Bannock Tribes of the Fort

¹³ To determine these categories, water years are grouped into "wet," "average or typical", and "dry". Wet years are based on the May 1 April–August water supply. The median elevation is then taken for each day within the group. Water years are categorized with respect to the forecasted runoff volume percentile: dry years represent the driest 20 percent, average years represent forecasts between 20 and 80 percent, and wet years represent greater than 80 percent. Grand Coulee use The Dalles forecast volumes. The minimum usable elevation for ferry operations of 1,229 feet (NAVGDS29) was identified through communications with ferry operators at the Colville Tribe (July 9, 2019).

8615 Hall Indian Reservation also tie the fate of salmon to the existence of their culture. Pacific
8616 lamprey is also important to the Nez Perce and other Indian tribes and has been impacted
8617 by the mainstem Columbia and Snake River dams. The four lower River treaty tribes (Nez
8618 Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, the Confederated
8619 Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands
8620 of the Yakama Nation), as well as state and Federal agencies, are currently working to
8621 restore and protect lamprey populations in the region (CRITFC 2019). This EIS assumes that
8622 ceremonial and subsistence fishing activities for Indian tribes as well as other subsistence
8623 fishers, including minority and low-income populations, would be relatively consistent with
8624 current levels under the No Action Alternative.

8625 **Power generation and transmission.** The average annual cost of electricity per household in
8626 Region C under the No Action Alternative would range from \$880 to \$1,100, depending on
8627 the county. Figure 3-235 illustrates the energy burden for households below the poverty
8628 level in low-income communities, minority communities, as well as on Indian tribal lands in
8629 Region C. As shown, the current total energy burden for these areas ranges from 7 to 19
8630 percent for these households. In contrast, households above the poverty level have energy
8631 burdens that range from 2 to 3 percent in Region C (DOE 2016). As noted above, energy
8632 burdens above 6 percent can be considered unaffordable. As such, low-income communities,
8633 minority communities, and Indian Tribes, and particularly low-income households in these
8634 communities, already experience potentially unaffordable energy burdens under the No
8635 Action Alternative in Region C. Any upward rate pressure in this region could impact low-
8636 income households, for whom energy costs are a larger percent of their income. In some
8637 cases, these low-income households are also minority, tribal, or both, but these impacts
8638 would occur across the region at level that would not be considered disproportionately high
8639 and adverse.



8640
 8641 **Figure 3-235. Percent of Household Income Spent on Energy (Energy Burden) for Households**
 8642 **Below Poverty Level - Region C**

8643 **Navigation and transportation.** Wheat farming occurring in Region C benefits from the
 8644 availability of low-cost barge transportation on the lower Snake and lower Columbia Rivers,
 8645 which allows for economical shipping of commodities from this region. Ports located along
 8646 the Snake River provide important development hubs for communities and help drive
 8647 economic development in the region. In addition, commercial activity associated with cruise

8648 ships is growing and brings visitors and tourist dollars to the municipalities along the river.
8649 Low-income and minority populations would benefit to some degree from tourism and
8650 employment from these activities under the No Action Alternative. Cruise ships typically
8651 board in the Portland area and travel downstream to Astoria as well as up the mainstem
8652 Columbia to departure points on the lower Snake River, typically near Clarkston,
8653 Washington. While cruise ship activity would be affected under MO3, effects of this change
8654 are not anticipated to be borne disproportionately by minority populations, low-income
8655 populations, or Indian tribes. The six cruise ships serving the Columbia River likely draw
8656 employees from the greater Portland area, and there is no evidence to suggest these
8657 employees are predominantly from environmental justice populations. As such, effects to
8658 cruise ships is not addressed further in this analysis.

8659 **Water supply.** As described in Section 3.12, *Water Supply*, three counties in Region C draw on
8660 surface water and groundwater for municipal and industrial use along the Snake River.
8661 Changes to the operations of Federal projects could affect access to diversions in these
8662 counties as well as the costs to deliver water. In addition, approximately 48,000 acres would
8663 be irrigated in counties along the Columbia River under the No Action Alternative in Region
8664 C. Based on unemployment claims for Washington State, the number of minority
8665 farmworkers in counties in the Ice Harbor and Lower Monumental water supply
8666 socioeconomic region is very small (less than 0.1 percent Hispanic) (WAESD 2019). In
8667 addition, less than 3 percent of farm producers (i.e., persons who are involved in making
8668 decisions for the farm operation) in these counties in Region C are Hispanic (NASS 2017).

8669 **Recreation.** As described in the Recreation section, total recreational visitation under the No
8670 Action Alternative in Region C is anticipated to be approximately 3.0 million visits annually,
8671 primarily associated with visitation at Lower Granite Dam and Reservoir, located near
8672 Lewiston, Idaho. The Nez Perce Tribe in Region C may engage in recreational activities in
8673 proximity to the affected recreation sites. Visitation to recreation areas also supports
8674 employment and spending in local areas around the recreation sites. The average annual
8675 regional economic contribution of recreational activity in terms of jobs and output is
8676 described in the Recreation section.

8677 **Cultural resources.** As detailed in Section 3.16.2.6., numerous traditional cultural properties are
8678 present in the vicinity of projects in Region C. Traditional cultural properties would continue
8679 to be adversely affected under the No Action Alternative due to ongoing operations and
8680 maintenance of the Columbia River System.

8681 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

8682 Approximately 45 percent of census block groups in Region D are classified as low-income or
8683 minority or both. Low-income and minority block groups are located near the McNary, John
8684 Day, The Dalles, and Bonneville Projects. There are also a number of Indian tribes with
8685 reservation lands and off-reservation trust lands in Region D, including the Confederated Tribes
8686 and Bands of the Yakama Nation, the Cowlitz Indian Tribe, the Confederated Tribes of the
8687 Warm Springs Reservation of Oregon, and the Confederated Tribes of the Umatilla Indian
8688 Reservation. A number of other Indian tribes also use Region D for fishing activities. Additional

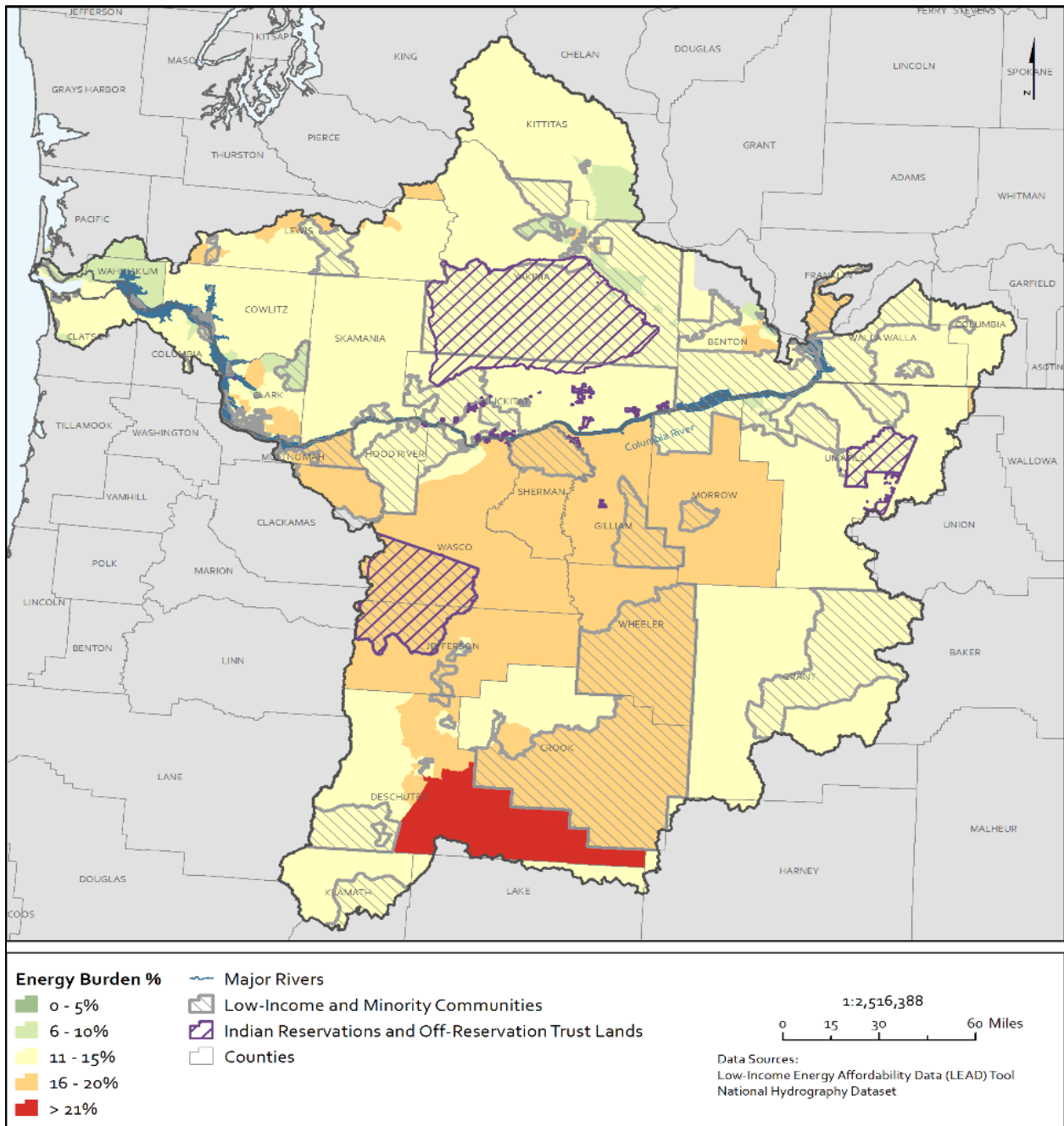
8689 anadromous fish species discussed in Regions B and C also contribute to tribal fisheries in
8690 Region D. A variety of ongoing activities would occur in Region D under the No Action
8691 Alternative that have the potential to affect minority populations, low-income populations, or
8692 Indian tribes. These include the following:

8693 **Fish.** Under the No Action Alternative, commercial, ceremonial and subsistence fishing activities
8694 are assumed to be relatively consistent with current levels. Ceremonial and subsistence
8695 fishing, particularly for salmon, steelhead, lamprey, and white sturgeon, is an important
8696 cultural, economic, and spiritual practice for Indian tribes from the Pacific Coast to the
8697 Puget Sound and even the Inland Northwest (PFMC 1999). Ceremonies represent the
8698 interdependence of all living things and demonstrate respect for the fish, both as living
8699 beings and a source of subsistence (PFMC 1999). Along the mainstem Columbia River, most
8700 tribal commercial fisheries occur between Bonneville and McNary Dams, in the “Zone 6”
8701 fishery. Tribal commercial salmon catch within Zone 6 of the Columbia River was valued at
8702 \$6.1 million in 2017 (PFMC 2018).¹⁴ Commercial fishing is an important source of income for
8703 some members of the Indian tribes in this region (NMFS 2014). Ceremonial and subsistence
8704 fishing take priority over commercial fishing. If a harvest is not sufficient for ceremonial and
8705 subsistence needs, fish will be taken from the commercial fishery stock to cover the deficit
8706 (NOAA 2018). The four Lower River treaty tribes (Nez Perce Tribe, Confederated Tribes of
8707 the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation
8708 of Oregon, and the Confederated Tribes and Bands of the Yakama Nation), as well as State
8709 and Federal agencies, are currently working to restore and protect lamprey populations in
8710 the region (CRITFC 2019). Fish are also an important component in the health of tribal
8711 members. Research indicates that loss of traditional food sources may put indigenous
8712 people at greater risk for a variety of diet-related illnesses. According to a 1994 CRITFC
8713 study, fish consumption is higher among the four Lower River treaty tribes than the general
8714 public. Some low-income and minority populations may participate in subsistence fishing
8715 throughout the region.

8716 **Power generation and transmission.** The average annual cost of electricity per household in
8717 Region D under the No Action Alternative would range from \$700 to \$1,200, depending on
8718 the county. Figure 3-236 illustrates the energy burden for households below the poverty
8719 level in low-income communities, minority communities, as well as on Indian Tribal lands in
8720 Region D. As shown, the current total energy burden for these areas ranges from 5 to 23
8721 percent for households. In contrast, households above the poverty level have energy
8722 burdens that range from 1 to 4 percent Region D (DOE 2016). As noted above, energy
8723 burdens above 6 percent can be considered unaffordable. As such, low-income
8724 communities, minority communities, and Indian tribes, and particularly low-income
8725 households in these communities, already experience potentially unaffordable energy
8726 burdens under the No Action Alternative in Region D. Any upward rate pressure in this
8727 region could impact low-income households, for whom energy costs are a larger percent of

¹⁴ Tribal commercial value data was only available for Chinook salmon and coho salmon and, even then, data is only for sales made to licensed fish buyers, not direct sales to the general public which may be substantial. Consequently, any valuation under-represents the total value of commercial sales made by tribal fisherman.

8728 their income. In some cases, these low-income households are also minority, tribal, or both
 8729 but these impacts would occur across the region at levels that would not be considered
 8730 disproportionately high and adverse.



8731
 8732 **Figure 3-236. Percent of Household Income Spent on Energy (Energy Burden) for Households**
 8733 **Below Poverty Level - Region D**

8734 **Navigation and transportation.** Wheat farming occurring in Region D benefits from the
 8735 availability of low-cost barge transportation which allows for economical shipping of
 8736 commodities, particularly grains, fuel, and chemicals. Shallow ports near the Tri-Cities area

8737 as well as large deep-water ports located along the lower Columbia River below Bonneville
8738 Dam provide important development hubs for communities and help drive economic
8739 development in this region. Cruise ships typically board in the Portland area and travel
8740 downstream to Astoria as well as up the mainstem Columbia to departure points on the
8741 lower Snake River, typically near Clarkston, Washington. While cruise ship activity passing
8742 through Region D would be affected under MO3, effects of this change are not anticipated
8743 to be borne disproportionately by minority populations, low-income populations, or Indian
8744 tribes.

8745 **Water supply:**

8746 ○ **Municipal and industrial use.** As described in Section 3.12, *Water Supply*, three counties
8747 in Region D draw on surface water and groundwater for municipal and industrial use
8748 along the Columbia River. The operations of Federal projects would continue to provide
8749 access to diversions in these counties under the No Action Alternative for municipal and
8750 industrial use.

8751 ○ **Irrigated farmland.** As described in Section 3.12, *Water Supply*, approximately 289,000
8752 acres are irrigated in counties along the Columbia River. Unemployment filings in 2018-
8753 19 in Washington suggest that approximately 73 percent of farmworkers in Region D are
8754 Hispanic (WAESD 2019). Approximately 11,600 jobs in Region D (in the John Day water
8755 supply socioeconomic area) would be supported by irrigated agriculture in Region D
8756 under the No Action Alternative.

8757 **Recreation.** As described in the Recreation section, total recreational visitation under the No
8758 Action Alternative in Region D is anticipated to be approximately 6.7 million visits annually,
8759 primarily associated with visitation at Lake Wallula, Lake Celilio, and Lake Bonneville. The
8760 tribes located in Region D may engage in recreational activities in proximity to the affected
8761 recreation sites. Visitation to recreation areas also supports employment and spending in
8762 local areas around the recreation sites. The average annual regional economic contribution
8763 of recreational activity in terms of jobs and output is described in the Recreation section.

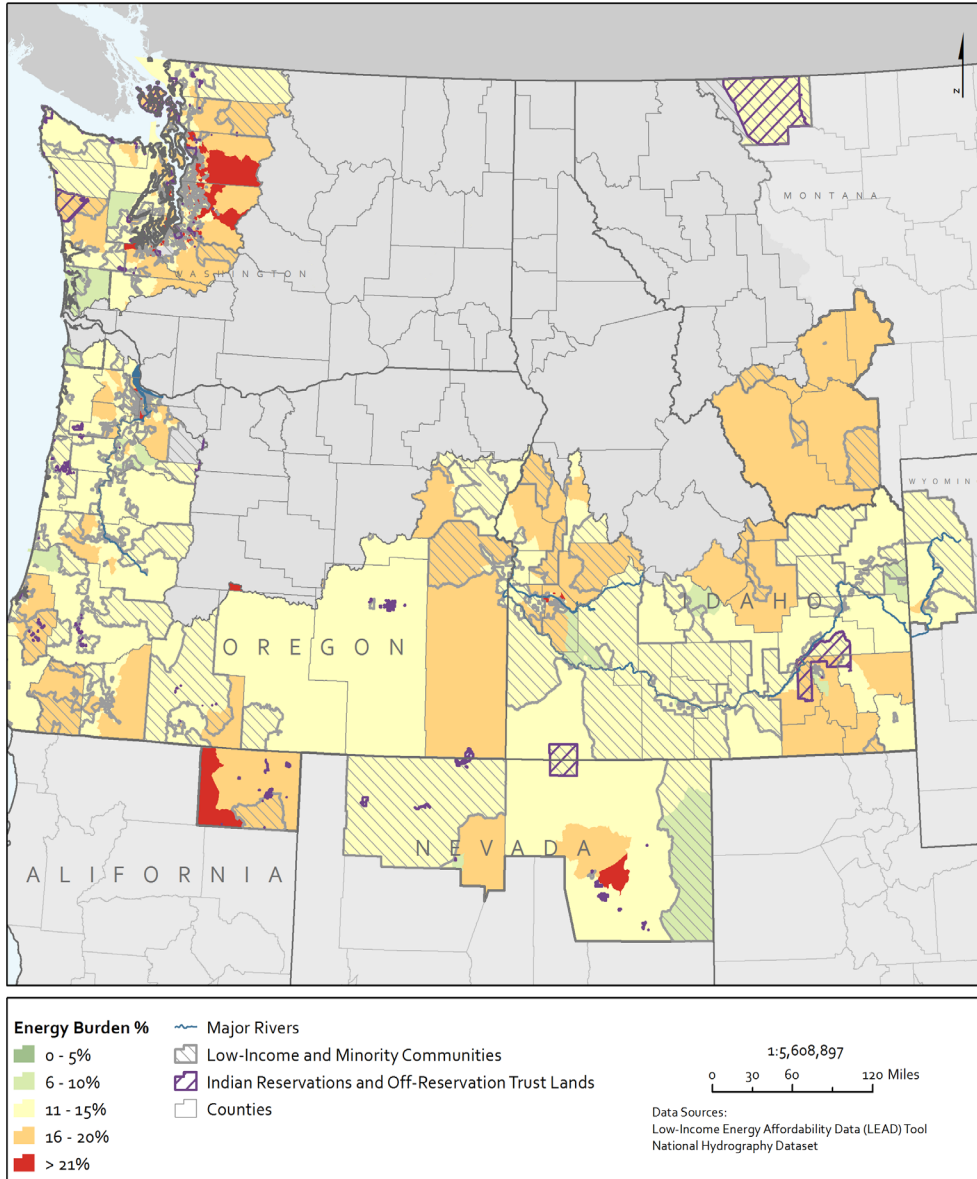
8764 **Cultural resources.** As detailed in Section 3.16.2.6., numerous traditional cultural properties are
8765 present in the vicinity of projects in Region D. Traditional cultural properties would continue
8766 to be adversely affected under the No Action Alternative due to ongoing operations and
8767 maintenance of the Columbia River System.

8768 **OTHER – AREAS OUTSIDE OF REGIONS A, B, C, AND D**

8769 As discussed in Section 3.15.1.2, the study area for the environmental justice analysis includes
8770 areas outside of Regions A, B, C, and D, where minority populations, low-income populations,
8771 or Indian tribes may be affected by the MOs. These primarily include the Bonneville service
8772 area, where effects may occur related to changes to hydropower operations or rates or both.

8773 **Power generation and transmission.** The average annual cost of electricity per household in
8774 the other areas (areas outside of Regions A–D but which may be affected by the MOs)
8775 would range from \$630 to \$1,500 depending on the county. Figure 3-237 illustrates the
8776 energy burden for households below and above the poverty level in other areas. As shown,

8777 the current energy burden by census tract ranges from 5 to 48 percent for households
 8778 below the Federal poverty level versus 1 to 4 percent for households above the Federal
 8779 poverty level in other areas (DOE 2016). As noted above, energy burdens above 6 percent
 8780 can be considered unaffordable. As such, most low-income households in other areas
 8781 already experience potentially unaffordable energy burdens under the No Action
 8782 Alternative. Any upward rate pressure in other areas could impact low-income households
 8783 for whom energy costs are a larger percent of their income. In some cases, these low-
 8784 income households are also minority, tribal, or both, but these impacts would occur across
 8785 the region at levels that would not be considered disproportionately high and adverse.



8786
 8787 **Figure 3-237. Percent of Household Income Spent on Energy (Energy Burden) for Households**
 8788 **Below Poverty Level – Other Areas**

8789 **SUMMARY OF EFFECTS—NO ACTION ALTERNATIVE**

8790 Under the No Action Alternative, effects from ongoing Columbia River System (CRS) operations
8791 on minority populations, low-income populations, and Indian tribes would continue. These
8792 ongoing impacts include the following:

8793 Ceremonial and subsistence fishing activities for Indian tribes as well as other subsistence
8794 fishers would be relatively consistent with current levels under the No Action Alternative
8795 throughout Regions A, B, C and D. Commercial fishing in Region D under the No Action
8796 Alternative would also be expected to be relatively consistent with current levels. Adverse
8797 effects associated with the absence or reduced levels of fish due to the operation and
8798 maintenance, or existence, of the CRS would continue under the No Action Alternative. Fish
8799 are an important component of the health of tribal members. Research indicates that loss
8800 of traditional food sources may put tribal community members at greater risk for a variety
8801 of diet-related illnesses. As described in Section 3.18.2, Tribal Perspectives, the construction
8802 of the dams and current system operations have ongoing effects on tribal culture, lifeways
8803 (e.g., customs and practices), and traditions. The loss of foundational aspects of tribal
8804 culture resulting from the inundation of important fishing sites and the reduction in wild
8805 salmon populations has adversely affected tribal communities.

8806 Low-income communities, minority communities, and Indian tribes, already experience
8807 potentially unaffordable energy burdens under the No Action Alternative throughout the
8808 study area; this is expected to continue under the No Action Alternative.

8809 Withdrawals of surface water and groundwater for municipal and industrial use along the
8810 Columbia River in Regions C and D are not expected to change under the No Action
8811 Alternative. Irrigated agriculture and associated employment would be expected to
8812 continue at existing levels along the Columbia River under the No Action Alternative in
8813 Regions C and D.

8814 Cultural resources in all regions would continue to be adversely affected under the No Action
8815 Alternative due to ongoing effects of inundation and reservoir fluctuation related to
8816 operations and maintenance of the CRS under the No Action Alternative.

8817 **3.18.3.5 Multiple Objective Alternative 1**

8818 Adverse effects related to the following resources may occur under MO1 depending upon the
8819 region: water quality, residential and anadromous fish, power generation and transmission,
8820 navigation and transportation, recreation and cultural resources. The effects of MO1 on
8821 environmental justice populations resulting from changes in these resources are described
8822 below by region. Note, the co-lead agencies engage in ongoing actions to improve conditions
8823 for fish, which include, but are not limited to, habitat restoration, hatcheries, invasive species
8824 control, and predator management. In addition to the resources identified under Section
8825 3.15.3.1, effects related to water supply on low-income, minority, and Indian tribes are
8826 anticipated to be negligible under MO1 because MO1 does not have any measures that would
8827 affect the ability to deliver water to meet current water supply.

8828 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

8829 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
8830 Region A under MO1 relative to the No Action Alternative, as follows:

8831 **Fish.** MO1 would have minor to moderate adverse effects to bull trout and Kootenai River
8832 white sturgeon, including adverse effects to food webs, varial zone at the mouth of
8833 tributaries that are important for migration, and habitat in Region A. Adverse effects on
8834 resident fish, including burbot, have the potential to adversely impact fishing opportunities
8835 in Region A for Indian tribes, and potentially other minority or low-income subsistence
8836 fishers in the Region.

8837 MO1 mitigation includes:

- 8838 ○ Plant 1- to 2-gallon cottonwoods near Bonners Ferry to improve habitat and floodplain
8839 connectivity. This would benefit ESA-listed Kootenai River White Sturgeon (KRWS) by
8840 providing a food source and complement ongoing habitat actions already being taken in
8841 the region.
- 8842 ○ On the Hungry Horse Reservoir, install structural components like woody debris and
8843 plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to
8844 stabilize the channels, increase cover for migrating fish, and improve the varial zone to
8845 minimize effects of reservoir fluctuation where the tributaries enter the reservoir.
- 8846 ○ On the Kootenai River, downstream of Libby, plant native wetland and riparian
8847 vegetation up to 100 acres along the river.
- 8848 ○ Update and implement Invasive Plant Management Plan for the shoreline at Libby.

8849 **Power generation and transmission.** Under MO1 upward or downward rate pressure may
8850 result in a change in the average annual cost of electricity per household in Region A
8851 ranging from a decrease of 0.21 percent to an increase of 3.1 percent compared to the No
8852 Action Alternative, or up to approximately \$28 per year compared to the No Action
8853 Alternative, depending on the county and the replacement portfolio. For census block
8854 groups in low-income populations, minority populations, or Indian tribes within the study
8855 area, this would represent an increase of approximately 0.035 percent of household income
8856 compared to an increase of 0.020 percent for other households in Region A. As discussed in
8857 the No Action Alternative, energy burdens in Region A are already likely unaffordable for
8858 most households with incomes below the Federal poverty level. Any downward rate
8859 pressure may be helpful for low-income households; however, energy burdens would likely
8860 remain unaffordable. Any upward rate pressure could impact low-income households, but
8861 these impacts would occur across the region at levels that would not be considered
8862 disproportionately high and adverse. In some cases, these low-income households are also
8863 minority, tribal, or both.

8864 **Navigation and transportation.** Commercial navigation, cruise ships, and ferries do not occur in
8865 Region A, thus no effects on navigation and transportation are anticipated to in Region A
8866 under MO1.

8867 **Recreation.** A less than one percent change in annual water-based recreation visitation due to
8868 effects on boat ramp accessibility at Hungry Horse Reservoir and Lake Koocanusa could
8869 occur under MO1; thus, any impacts are expected to be negligible.

8870 **Cultural resources.** Effects to traditional cultural properties to projects within Region A appear
8871 to be minor at Hungry Horse. These effects are related to increase exposure and amplitude
8872 of reservoir elevation changes relative to the NAA. No change to traditional cultural
8873 properties relative to the NAA is expected at Albeni Falls. The Bear Paw Rock sacred site
8874 would experience no change relative to the NAA. Effects to cultural resources would be
8875 mitigated through the ongoing Federal Columbia River Power System program.

8876 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

8877 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
8878 Region B under MO1 relative to the No Action Alternative, as follows:

8879 **Fish.** MO1 would range from negligible and minor, to localized moderate adverse effects to
8880 resident fish (kokanee, redband rainbow trout, white sturgeon, and burbot) in Lake
8881 Roosevelt stemming from increased entrainment, kokanee and burbot egg stranding, and
8882 varial zone effects at the mouth of tributaries that are important for migration. There would
8883 be minor adverse effects due to reduction in sturgeon recruitment in Region B. Adverse
8884 effects on resident fish have the potential to adversely impact fishing opportunities in
8885 Region B for Indian tribes, as well as other minority or low-income subsistence fishers in the
8886 Region. Effects to Indian tribes based on changes in salmon and steelhead abundance in
8887 Region B below Chief Joseph Dam are expected to be negligible compared to the No Action
8888 Alternative.

8889 MO1 mitigation includes developing additional spawning habitat at Lake Roosevelt to minimize
8890 impacts to non-listed resident fish.

8891 **Power generation and transmission.** Under MO1 the upward or downward rate pressure may
8892 result in a change in the average annual cost of electricity per household in Region B ranging
8893 from a decrease of 0.48 percent to an increase of 4.2 percent compared to the No Action
8894 Alternative, or up to approximately \$41 per year compared to the No Action Alternative,
8895 depending on the county and the replacement portfolio. For census block groups in low-
8896 income populations, minority populations, or Indian tribes within the study area, this would
8897 represent an increase of approximately 0.037 percent of household income compared to an
8898 increase of 0.020 percent for other households in Region B. As discussed in the No Action
8899 Alternative, energy burdens in Region B are already likely unaffordable for most households
8900 with incomes below the Federal poverty level. Any upward rate pressure could impact low-
8901 income households, but these impacts would occur across the region at levels that would not
8902 be considered disproportionately high and adverse. In some cases, these low-income
8903 households are also minority, tribal, or both. Payments to the CTCR, which are based on
8904 Bonneville power sales revenue and generation at Grand Coulee Dam, are expected to
8905 increase up to approximately 1 percent. The Spokane Tribe of Indians will also begin receiving
8906 payments based on Bonneville power sales revenue and generation at Grand Coulee Dam.

8907 That payment is expected to begin in 2021 and under MO1 is expected to increase up to
8908 approximately 1 percent.

8909 **Navigation and transportation.** Ferry operations on Lake Roosevelt could be affected under
8910 MO1 due to anticipated drawdowns. In wet years, when Lake Roosevelt's draw down for
8911 flood risk management begins sooner than for the No Action Alternative, the Inchelium-
8912 Gifford Ferry on Lake Roosevelt would not be able to operate for approximately 36 days of
8913 the year, which is nine additional days than anticipated under the No Action Alternative in
8914 wet years at this location. The Inchelium-Gifford Ferry is operated by the CTCR, and
8915 provides commuters, schoolchildren, tourists, and others with transportation for daily
8916 activities including commuting to work, accessing health care, and participating in
8917 educational activities. When the ferry is not in service, the next nearest Columbia River
8918 crossing is approximately 34 miles to the north on WA20/US395 and WA25/US395. This
8919 moderate effect would primarily fall on the CTCR.

8920 **Recreation.** A less than one percent change in water-based recreation visitation due to effects
8921 on boat ramp accessibility at Lake Roosevelt could occur under MO1; thus, any impacts are
8922 expected to be negligible.

8923 **Cultural resources.** Implementation of MO1 could negatively affect traditional cultural
8924 properties through increasing exposure and erosion of reservoir areas associated with
8925 increased reservoir level fluctuations.¹⁵ Specifically, MO1 would increase the exposure of
8926 properties at Grand Coulee Dam (Lake Roosevelt) by 10 percent in terms of acre-days of
8927 exposure and would increase the frequency of reservoir elevation changes by
8928 approximately 32 percent. The resulting effects are expected to be major. Increases in
8929 exposure of Hayes Island (one of the main features at Kettle Falls), due to longer and more
8930 frequent drawdown periods, may lead to potential looting. This increased exposure may
8931 also allow some increased access for tribal religious practitioners, although such temporary
8932 access may not be perceived as beneficial. The effect on the Kettle Falls sacred site is
8933 expected to be minor relative to the No Action Alternative. Effects to cultural resources
8934 would be mitigated through the ongoing Federal Columbia River Power System cultural
8935 resource program.

8936 **REGION C - DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
8937 **HARBOR DAMS**

8938 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
8939 Region C under MO1 relative to the No Action Alternative, as follows:

8940 **Fish.** MO1 would have mixed effects ranging from negligible beneficial (due to increased
8941 opportunity for non-powerhouse dam passage), to minor adverse effects to resident fish
8942 due to warmer summer water temperatures, reduced flows, or increased TDG and potential
8943 for gas bubble trauma in Region C. Effects to anadromous fish range from potential
8944 negligible beneficial increases to moderate increases depending on latent mortality
8945 assumptions. Some species are anticipated to have the potential for minor adverse effects,
8946 particularly to sockeye salmon and fall Chinook salmon based on warmer summer water

¹⁵ Chief Joseph was not analyzed due to a lack of substantial operational or structural changes.

8947 temperatures. Any minor adverse effects on resident and anadromous fish would have the
8948 potential to adversely impact fishing opportunities in Region C for Indian tribes, as well as
8949 low-income and minority subsistence fishers in the Region, while moderate increases in
8950 anadromous fish returns would have a beneficial impact.

8951 MO1 mitigation includes the temporary extension of performance standard spill levels, in
8952 coordination with the Regional Forum.

8953 **Power generation and transmission.** Under MO1 upward or downward rate pressure may
8954 result in a change in the average annual cost of electricity per household in Region C ranging
8955 from a decrease of 0.31 to an increase of 3.0 percent compared to the No Action
8956 Alternative, or up to approximately \$27 per year compared to the No Action Alternative,
8957 depending on the county and the replacement portfolio. For census block groups in low-
8958 income populations, minority populations, or Indian tribes within the study area, this would
8959 represent an increase of approximately 0.023 percent of household income compared to an
8960 increase of 0.011 percent for other households in Region C. As discussed in the No Action
8961 Alternative, energy burdens in Region C are already likely unaffordable for all households
8962 with incomes below the Federal poverty level. Any upward rate pressure could impact low-
8963 income households, but these impacts would occur across the region at levels that would
8964 not be considered disproportionately high and adverse. In some cases, these low-income
8965 households are also minority, tribal or both.

8966 **Navigation and transportation** Effects on navigation and transportation are anticipated to be
8967 negligible in Region C under MO1 given that average annual cost increases represent less
8968 than 0.1 percent of total costs of navigation operations.

8969 **Recreation.** A less than one percent change in water-based recreation visitation due to effects
8970 on boat ramp accessibility at Dworshak Reservoir may occur under MO1. A negligible to
8971 minor and adverse effect on the quality of water-based reservoir recreation is expected in
8972 Region C with the exception of the Clearwater River. In the Clearwater River, there is the
8973 potential for localized major adverse effects to recreational fishing along the Clearwater
8974 River in August and September due to increased turbidity from changes in outflows from
8975 Dworshak Dam. To the extent that low-income populations, minority populations or tribal
8976 populations in this region would have participated in the recreation activities or been
8977 employed in recreation-based jobs, impacts to environmental justice populations may
8978 occur. Information is not available regarding the makeup of recreational fishing participants
8979 along the Clearwater River; however, this is a very well-known site for steelhead fishing.
8980 While some of the businesses operating recreational fishing tours or some of the
8981 recreational participants may be low-income, minority or tribal; low-income populations,
8982 minority populations, and Indian tribes are not expected to comprise the majority of these
8983 affected visitors. As such, disproportionately high and adverse effects are not anticipated.

8984 **Cultural resources.** Implementation of MO1 could adversely affect traditional cultural
8985 properties through increasing exposure and erosion associated with increased reservoir
8986 level fluctuations. Specifically, MO1 is expected to affect traditional cultural properties due
8987 to an increase in the number of high draft rate events at Dworshak Dam by over 100

8988 percent as compared to the No Action Alternative resulting in major effects. However, some
8989 of the effects may prove to be beneficial as the increased high draft rate events could lead
8990 to increased access and visibility of properties. Effects to cultural resources would be
8991 mitigated through the ongoing Federal Columbia River Power System program.

8992 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

8993 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
8994 Region D under MO1 relative to the No Action Alternative, as follows:

8995 **Fish.** MO1 would have mixed effects ranging from negligible beneficial (due to increased
8996 opportunity for non-powerhouse dam passage), to minor adverse effects to resident fish
8997 due to warmer summer water temperatures, changes in John Day pool elevation, reduced
8998 flows, or increased TDG and potential for gas bubble trauma in Region D. Effects to
8999 anadromous fish range from potential negligible beneficial increases to moderate increases
9000 depending upon latent mortality assumptions. Some species are anticipated to have the
9001 potential for minor adverse effects, particularly to sockeye salmon and fall Chinook salmon
9002 based on warmer summer water temperatures. Adverse effects on resident and
9003 anadromous fish would have the potential to adversely impact fishing opportunities in
9004 Region D for Indian tribes, as well as low-income and minority subsistence fishers in the
9005 Region, while moderate increases in anadromous fish returns would have a beneficial
9006 impact.

9007 MO1 mitigation includes the temporary extension of performance standard spill levels, in
9008 coordination with the regional forum.

9009 **Power generation and transmission.** Under MO1 the upward or downward rate pressure may
9010 result in a change in the average annual cost of electricity per household in Region D that
9011 would range from a decrease of 0.29 to an increase of 7.6 percent compared to the No
9012 Action Alternative, or up to approximately \$64 per year compared to the No Action
9013 Alternative, depending on the county and the replacement portfolio. For census block
9014 groups in low-income populations, minority populations, or Indian tribes within the study
9015 area, this would represent an increase of approximately 0.050 percent of household income
9016 compared to an increase of 0.037 percent for other households in Region D. As discussed in
9017 the No Action Alternative, energy burdens in Region D are already likely unaffordable for
9018 most households with incomes below the Federal poverty level. Any upward rate pressure
9019 could impact low-income households, but these impacts would occur across the region at
9020 levels that would not be considered disproportionately high and adverse. In some cases,
9021 these low-income households are also minority, tribal, or both.

9022 **Navigation and transportation.** Effects on navigation and transportation are anticipated to be
9023 negligible in Region D under MO1 given that average annual cost increases represent less
9024 than 0.1 percent of total costs of navigation operations.

9025 **Recreation.** No changes in annual water-based recreation visitation associated with changes in
9026 boat ramp accessibility would occur under MO1. Minor effects to quality of fishing, hunting,

9027 wildlife viewing, swimming, and water sports associated with changing river and reservoir
9028 conditions may occur.

9029 **Cultural Resources.** Effects on traditional cultural properties are anticipated to be consistent
9030 with the NAA in Region D under MO1.

9031 **OTHER – AREAS OUTSIDE OF REGIONS A, B, C, AND D**

9032 Because effects on resources would be primarily limited to Regions A, B, C, and D, effects on
9033 minority populations, low-income populations, or Indian tribes outside of Regions A, B, C, and D
9034 would not be anticipated relative to the No Action Alternative under MO1 other than for power
9035 generation and transmission.

9036 **Power generation and transmission.** Under MO1, upward or downward rate pressure may
9037 result in a change in the average annual cost of electricity per household in other areas
9038 ranging from a decrease of 0.33 percent to an increase of 4.9 percent compared to the No
9039 Action Alternative, or up to approximately \$42 per year compared to the No Action
9040 Alternative, depending on the county and the replacement portfolio. For census block
9041 groups in low-income populations, minority populations, or Indian tribes within the study
9042 area, this would represent an increase of approximately 0.018 percent of household income
9043 compared to an increase of 0.014 percent for other households in this area. As discussed in
9044 the No Action Alternative, energy burdens in other areas are already likely unaffordable for
9045 most households with incomes below the Federal poverty level. Any downward rate
9046 pressure may be helpful for low-income households; however, energy burdens would likely
9047 remain unaffordable. Any upward rate pressure could impact low-income households, but
9048 these impacts would occur across the region at levels that would not be considered
9049 disproportionately high and adverse.

9050 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 1**

9051 Through analysis considering effects detailed in Chapter 3 Affected Environment and
9052 Environmental Consequences; Chapter 4 Climate; Chapter 5 Mitigation; and Chapter 6
9053 Cumulative Effects there would not likely be a disproportionately high and adverse effect on
9054 environmental justice populations for MO1.

9055 **3.18.3.6 Multiple Objective Alternative 2**

9056 Adverse effects related to the following resources may occur under MO2: fish, navigation and
9057 transportation, recreation and cultural resources. Effects to power and generation costs could
9058 vary between adverse and beneficial. The effects of MO2 on environmental justice populations
9059 resulting from changes in these resources are described below by region. Note, the co-lead
9060 agencies engage in ongoing actions to improve conditions for fish, which include, but are not
9061 limited to, habitat restoration, hatcheries, invasive species control, and predator management.
9062 In addition to the resources identified in Section 3.15.3.1, effects related to water supply on
9063 low-income, minority, and Indian tribes are anticipated to be negligible under MO2 because

9064 MO2 does not have any measures that would affect the ability to deliver water to meet current
9065 water supply.

9066 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

9067 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
9068 Region A under MO2 relative to the No Action Alternative, as follows:

9069 **Fish.** Resident fish species would experience minor to moderate, and in some locations major
9070 localized adverse effects from higher winter flows anticipated under MO2 downstream of
9071 Libby Dam on the Kootenai River in the late fall and downstream of Hungry Horse Dam in
9072 the winter. Resident fish species may also experience moderate adverse effects from
9073 reduced aquatic food production in Hungry Horse reservoir, increased varial zone effects to
9074 tributaries, and potential increased fish entrainment. In addition, reduced spring freshet
9075 would reduce sturgeon habitat on the Kootenai River. These effects have the potential to
9076 adversely affect fishing opportunities in Region A for Indian tribes, as well as low-income
9077 and minority subsistence fishers in the Region. MO2 mitigation includes:

- 9078 ○ Plant 1- to 2-gallon cottonwoods near Bonners Ferry to improve habitat and floodplain
9079 connectivity. This would benefit ESA-listed Kootenai River White Sturgeon (KRWS) by
9080 providing a food source and complement ongoing habitat actions already being taken in
9081 the region.
- 9082 ○ On the Hungry Horse Reservoir, install structural components like woody debris and
9083 plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to
9084 stabilize the channels, increase cover for migrating fish, and improve the varial zone to
9085 minimize effects of reservoir fluctuation where the tributaries enter the reservoir.
- 9086 ○ On the Kootenai River, downstream of Libby, plant native wetland and riparian
9087 vegetation up to 100 acres along the river.
- 9088 ○ Update and implement Invasive Plant Management Plan for the shoreline at Libby.

9089 **Power generation and transmission.** Under MO2 upward or downward rate pressure may
9090 result in a change in the average annual cost of electricity per household in Region A
9091 ranging from a decrease of 0.61 percent to an increase of less than 0.01 percent, or up less
9092 than \$1 per year compared to the No Action Alternative, depending on the county. This
9093 change represents 0.01 percent of median household income for households in Region A, a
9094 negligible portion of median household income for all households in Region A. As discussed
9095 in the No Action Alternative, energy burdens in Region A are already likely unaffordable for
9096 all households with incomes below the Federal poverty level. Any downward rate pressure
9097 may be helpful for low-income households; however, energy burdens would likely remain
9098 unaffordable in this region. Any upward rate pressure could impact low-income households,
9099 but these impacts would occur across the region at levels that would not be considered
9100 disproportionately high and adverse. In some cases, these low-income households are also
9101 minority, tribal, or both.

9102 **Recreation.** A less than one percent change in water-based recreation visitation due to effects
9103 on boat ramp accessibility at Hungry Horse Reservoir and Lake Koocanusa would occur
9104 under MO2. Resident fish species may be adversely impacted from higher winter flows
9105 anticipated under MO2. There would be additional minor adverse effects to the water
9106 quality and waterbird populations related to changes in habitat conditions.

9107 **Cultural resources.** Implementation of MO2 could adversely affect traditional cultural
9108 properties through increasing exposure and erosion associated with increased reservoir
9109 level fluctuations. At the Hungry Horse Project, the exposure of traditional cultural
9110 properties and amplitude of elevation changes would result in moderate effects. The Bear
9111 Paw Rock sacred site would experience no change relative to the NAA. Effects to cultural
9112 resources would be mitigated through the ongoing Federal Columbia River Power System
9113 program.

9114 **REGION B - GRAND COULEE AND CHIEF JOSEPH DAMS**

9115 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
9116 Region B under MO2 relative to the No Action Alternative, as follows:

9117 **Fish.** Increased entrainment risk for some resident species (bull trout, kokanee, rainbow trout,
9118 and burbot), increased burbot and kokanee egg desiccation, and tributary access issues for
9119 redband rainbow trout could cause minor to moderate adverse effects to fish in Lake
9120 Roosevelt in Region B under MO2. Upper Columbia River salmon and steelhead would
9121 experience a negligible adverse impact in Region B below Chief Joseph Dam. These effects
9122 have the potential to have a negligible to minor adverse effect to fishing opportunities for
9123 Indian tribes, as well as low-income and minority subsistence fishers in the Region.

9124 MO2 mitigation includes developing additional spawning habitat at Lake Roosevelt to minimize
9125 impacts to non-listed resident fish.

9126 **Power generation and transmission.** Under MO2 upward or downward rate pressure may
9127 result in a change in the average annual cost of electricity per household in Region B ranging
9128 from a decrease of 1.3 percent to an increase of 0.46 percent, or up to approximately \$4.50
9129 per year compared to the No Action Alternative, depending on the county. This change
9130 represents less than 0.01 percent of median household income for households in Region B.
9131 As discussed in the No Action Alternative, energy burdens in Region B are already likely
9132 unaffordable for most households with incomes below the Federal poverty level. Any
9133 downward rate pressure in Region B may reduce the number of low-income households
9134 where energy burdens are unaffordable. Any upward rate pressure could impact low-
9135 income households, but these impacts would occur across the region at levels that would
9136 not be considered disproportionately high and adverse. In some cases, these low-income
9137 households are also minority, tribal, or both. Payments to the CTCR, which are based on
9138 Bonneville power sales revenue and generation at Grand Coulee Dam are expected to
9139 decrease by approximately 2%. The Spokane Tribe of Indians will also begin receiving
9140 payments based on Bonneville power sales revenue and generation at Grand Coulee Dam.

9141 That payment is expected to begin in 2021 and under MO2 is expected to decrease by
9142 approximately 2%.

9143 **Navigation and transportation.** Ferry operations on Lake Roosevelt could be affected under
9144 MO2 due to anticipated drawdowns in wet years. In wet years, the Inchelium-Gifford Ferry
9145 on Lake Roosevelt would not be able to operate for approximately 36 days in the year,
9146 which is 9 more days than anticipated under the No Action Alternative in wet years at this
9147 location. The Inchelium-Gifford Ferry is operated by the CTRC, and provides commuters,
9148 schoolchildren, tourists, and others with transportation for daily activities including
9149 commuting to work, accessing health care, and participating in educational activities. When
9150 the ferry is not in service, the next nearest Columbia River crossing is approximately 34
9151 miles to the north on WA20/US395 and WA25/US395. This moderate effect would primarily
9152 fall on the CTRC.

9153 **Recreation.** Effects on recreation are anticipated to be negligible in Region B under MO2.

9154 **Cultural resources.** Implementation of MO2 could adversely affect traditional cultural
9155 properties through increasing exposure and erosion associated with increased reservoir
9156 level fluctuations.¹⁶ Specifically, MO2 would increase the exposure of traditional cultural
9157 properties coupled with the increased frequency of elevation changes would cause
9158 moderate effects. Increases in exposure of Hayes Island (one of the main features at Kettle
9159 Falls), due to longer and more frequent drawdown periods, may lead to potential looting.
9160 This increased exposure may also allow some increased access for tribal religious
9161 practitioners, although such temporary access may not be perceived as beneficial. The
9162 effect on the Kettle Falls sacred site is expected to be minor relative to the No Action
9163 Alternative. Effects to cultural resources would be mitigated through the ongoing Federal
9164 Columbia River Power System program.

9165 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
9166 **HARBOR DAMS**

9167 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
9168 Region C under MO2 relative to the No Action Alternative, as follows:

9169 **Fish.** Under MO2, decreased abundance of Snake River spring Chinook salmon and Snake River
9170 steelhead predicted by the CSS model (LCM predicted a minor increase) would contribute to
9171 minor beneficial effects (LCM) to major adverse effects (CSS) on other fishing opportunities
9172 in Region C. Adverse effects to kokanee at Dworshak Reservoir are also anticipated. These
9173 modeled changes could range from minor benefits to a major adverse impact to Indian
9174 tribes in the region for whom salmon and steelhead are a predominant element of cultural
9175 traditions and traditional diet, as well as sources of revenue. Low-income and minority
9176 subsistence fishers in the Region could also be affected.

9177 **Power generation and transmission.** Under MO2 downward rate pressure may result in a
9178 decrease in the average annual cost of electricity per household in Region C ranging from a

¹⁶ Chief Joseph was not analyzed due to a lack of substantial operational or structural changes.

9179 decrease of 0.82 to an increase of 0.20 percent, or up to approximately \$2 per year
9180 compared to the No Action Alternative, depending on the county. This change represents
9181 less than 0.01 percent of median household income for households in Region C. As
9182 discussed in the No Action Alternative, energy burdens in Region C are already likely
9183 unaffordable for all households with incomes below the Federal poverty level. Any
9184 downward rate pressure may be helpful for low-income households; however, energy
9185 burdens would likely remain unaffordable in this region.

9186 **Navigation and transportation.** Negligible effects would be anticipated for commercial
9187 navigation or commercial cruise lines in Region C under MO2. Average annual cost increases
9188 represent less than 0.1 percent of total costs of navigation operations. No effects to ferry
9189 operations are anticipated in Region C.

9190 **Recreation.** A minor (6.5 percent) decrease in water-based recreation visitation due to effects
9191 on boat ramp accessibility at Dworshak Reservoir would occur under MO2. This would
9192 reduce visitation by approximately 12,000 annual visits. Some portion of the visits to
9193 Dworshak Reservoir may be attributable to low-income populations, minority populations,
9194 and Indian tribes (particularly Nez Perce Tribe) that reside in relative proximity to the
9195 affected recreation sites. Minor additional adverse effects to quality of fishing, hunting,
9196 wildlife viewing, swimming, and water sports associated with changes in water quality and
9197 wetland habitat conditions on the Snake River.

9198 **Cultural resources.** Implementation of MO2 could adversely affect traditional cultural
9199 properties through increasing exposure and erosion associated with increased reservoir
9200 level fluctuations. MO2 could result in moderate effects to TCPs at Dworshak Reservoir
9201 where TCPs are present in the drawdown zone by allowing for wider and more frequent
9202 range of shifts in reservoir elevations. Under MO2, effects to cultural resources near the
9203 lower Snake River projects are expected to be minor as compared to the No Action
9204 Alternative. Effects to cultural resources would be mitigated through the ongoing Federal
9205 Columbia River Power System program.

9206 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

9207 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
9208 Region D under MO2 relative to the No Action Alternative, as follows:

9209 **Fish.** Resident fish effects in Region D from MO2 would be negligible. Under MO2, decreased
9210 abundance of Snake River spring Chinook salmon and Snake River steelhead, upper
9211 Columbia River spring Chinook salmon, and decreased in-river survival rates of upper
9212 Columbia River steelhead predicted by the CSS model would contribute to major adverse
9213 effects on other fishing opportunities in the Columbia River in Region D. Minor to moderate
9214 increases in Snake River Chinook abundance predicted by the LCM would have a minor
9215 beneficial effect. These modeled changes could represent a range of potential impacts to
9216 Indian tribes in the region, for whom salmon and steelhead are a predominant element of
9217 cultural traditions and traditional diet, as well as sources of revenue. Low-income and
9218 minority subsistence fishers in the Region could also be affected.

9219 **Power generation and transmission.** Under MO2 upward or downward rate pressure may
9220 result in a change in the average annual cost of electricity per household in Region D would
9221 ranging from a decrease of 0.85 percent to an increase of 0.26 percent, or up to
9222 approximately \$3 per year compared to the No Action Alternative, depending on the
9223 county. This represents a negligible portion of median household income for households in
9224 Region D. As discussed in the No Action Alternative, energy burdens in Region D are already
9225 likely unaffordable for most households with incomes below the Federal poverty level. Any
9226 downward rate pressure in Region D may reduce the number of low-income households
9227 where energy burdens are unaffordable. Any upward rate pressure could impact low-
9228 income households, but these impacts would occur across the region at levels that would
9229 not be considered disproportionately high and adverse. In some cases, these low-income
9230 households are also minority, tribal, or both.

9231 **Navigation and transportation.** Effects to navigation and transportation are anticipated to be
9232 negligible in this region given that average annual cost increases represent less than 0.1
9233 percent of total costs of navigation operations.

9234 **Recreation.** No changes in annual water-based recreation visitation associated with changes in
9235 boat ramp accessibility would occur under MO2. Negligible to minor adverse effects to
9236 quality of fishing, hunting, wildlife viewing, swimming, and water sports would occur
9237 associated with minor changes in river conditions on the lower Columbia River.

9238 **Cultural resources.** Effects to cultural resources are anticipated to be minor at John Day and no
9239 change in relation to the NAA at McNary, The Dalles, or Bonneville. Effects to cultural
9240 resources would be mitigated through the ongoing Federal Columbia River Power System
9241 program.

9242 **OTHER – AREAS OUTSIDE OF REGIONS A, B, C, AND D**

9243 Because effects on resources would be primarily limited to Regions A, B, C, and D, effects on
9244 minority populations, low-income populations, or Indian tribes outside of Regions A, B, C, and D
9245 would not be anticipated relative to the No Action Alternative under MO2 other than for power
9246 generation and transmission.

9247 **Power generation and transmission.** Under MO2 upward or downward rate pressure may
9248 result in a change in the average annual cost of electricity per household in other areas
9249 ranging from a decrease of 0.86 percent to an increase of 0.10 percent, or up to
9250 approximately \$1 per year compared to the No Action Alternative, depending on the
9251 county. This represents a negligible portion of median household income for households in
9252 these areas. As discussed in the No Action Alternative, energy burdens in other areas are
9253 already likely unaffordable for most households with incomes below the Federal poverty
9254 level. Any downward rate pressure in this region may reduce the number of low-income
9255 households where energy burdens are unaffordable. Any upward rate pressure could
9256 impact low-income households, but these impacts would occur across the region at levels
9257 that would not be considered disproportionately high and adverse. In some cases, these
9258 low-income households are also minority, tribal, or both.

9259 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 2**

9260 Through analysis considering effects detailed in Chapter 3 Affected Environment and
9261 Environmental Consequences; Chapter 4 Climate; Chapter 5 Mitigation; and Chapter 6
9262 Cumulative Effects there would not likely be a disproportionately high and adverse effect on
9263 environmental justice populations for MO2.

9264 **3.18.3.7 Multiple Objective Alternative 3**

9265 Adverse effects related to the following resources are expected under MO3: fish, power
9266 generation and transmission, navigation and transportation, water supply, recreation and
9267 cultural resources. The effects of MO3 on environmental justice populations resulting from
9268 changes in these resources are described below by region. Note, the co-lead agencies engage in
9269 ongoing actions to improve conditions for fish, which include, but are not limited to, habitat
9270 restoration, hatcheries, invasive species control, and predator management. As discussed in
9271 Section 3.7, *Power Generation and Transmission*, Indian tribes could also be affected by
9272 changes in the Bonneville F&W Program funding under MO3, which would decrease by
9273 approximately \$32 million at least. Given that the lower Snake River dams would no longer be
9274 in place to operate, Bonneville's funding for the effects of construction and operation of these
9275 dams through the lower Snake River Compensation Plan programs would cease.

9276 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

9277 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
9278 Region A under MO3 relative to the No Action Alternative, as follows:

9279 **Fish.** Similar to MO1, there could be minor to moderate adverse effects to food webs, varial
9280 zones at the mouth of tributaries that are important for migration, and habitat for bull
9281 trout, Kootenai River White Sturgeon, and other native fish in Region A. Effects on resident
9282 fish have the potential to adversely impact fishing opportunities in Region A for Indian
9283 tribes, as well as low-income and minority subsistence fishers in the Region.

9284 MO3 mitigation includes:

- 9285 ○ Plant 1- to 2-gallon cottonwoods near Bonners Ferry to improve habitat and floodplain
9286 connectivity. This would benefit ESA-listed Kootenai River White Sturgeon (KRWS) by
9287 providing a food source and complement ongoing habitat actions already being taken in
9288 the region.
- 9289 ○ On the Hungry Horse Reservoir, install structural components like woody debris and
9290 plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to
9291 stabilize the channels, increase cover for migrating fish, and improve the varial zone to
9292 minimize effects of reservoir fluctuation where the tributaries enter the reservoir.
- 9293 ○ On the Kootenai River, downstream of Libby, plant native wetland and riparian
9294 vegetation up to 100 acres along the river.
- 9295 ○ Update and implement Invasive Plant Management Plan for the shoreline at Libby.

9296 **Power generation and transmission.** Under MO3 upward rate pressure may result in an
9297 increase in the average annual cost of electricity per household in Region A of 0.21 to 7.2
9298 percent compared to the No Action Alternative, or up to approximately \$71 per year
9299 compared to the No Action Alternative, depending on the county and the replacement
9300 portfolio. For census block groups in low-income populations, minority populations, or
9301 Indian tribes within the study area, this would represent an increase of approximately 0.17
9302 percent of household income compared to an increase of 0.11 percent for other households
9303 in Region A. As discussed for the No Action Alternative, energy burdens in Region A are
9304 already likely unaffordable for the all households with incomes below the poverty level. Any
9305 upward rate pressure could impact low-income households, but these impacts would occur
9306 across the region at levels that would not be considered disproportionately high and
9307 adverse. In some cases, these low-income households are also minority, tribal, or both.

9308 **Recreation.** A less than one percent change in annual water-based recreation visitation due to
9309 effects on boat ramp accessibility at Hungry Horse Reservoir and Lake Koocanusa would
9310 occur under MO3.

9311 **Cultural resources** In Region A, implementation of MO3 would result in no change to traditional
9312 cultural properties relative to the NAA. The Bear Paw Rock sacred site would experience no
9313 change relative to the NAA.

9314 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

9315 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
9316 Region B under MO3 relative to the No Action Alternative, as follows:

9317 **Fish.** Predicted effects range from negligible decreases in steelhead in-river migration survival
9318 to variable increases in the abundance of anadromous species such as spring Chinook below
9319 Chief Joseph Dam are anticipated due to higher spill under MO3 depending on latent
9320 mortality assumptions. These modeled effects are mixed but improved conditions could
9321 increase opportunities for fishing for these species over the long term in Region B below
9322 Chief Joseph Dam. Effects to resident fish would range from minor adverse effects from
9323 increased wintertime entrainment to minor beneficial effects due to reduced risk of
9324 kokanee and burbot egg stranding. Many of the relationships considered for resident fish
9325 would have no effect compared to the No Action Alternative. As such, adverse effects to
9326 low-income or minority populations or Indian tribes are not anticipated.

9327 MO3 mitigation includes developing additional spawning habitat at Lake Roosevelt to minimize
9328 impacts to non-listed resident fish.

9329 **Power generation and transmission.** Under MO3 upward rate pressure may result in an
9330 increase in the average annual cost of electricity per household in Region B of 0.21 to 11.3
9331 percent, or up to approximately \$110 per year, compared to the No Action Alternative,
9332 depending on the county and the replacement portfolio. For census block groups in low-
9333 income populations, minority populations, or Indian tribes within the study area, this would
9334 represent an increase of approximately 0.10 percent of household income compared to an
9335 increase of 0.056 percent for other households in Region B. As discussed for the No Action

9336 Alternative, energy burdens in Region B are already likely unaffordable for most households
9337 with incomes below the Federal poverty level. Any upward rate pressure could impact low-
9338 income households, but these impacts would occur across the region at levels that would
9339 not be considered disproportionately high and adverse. In some cases, these low-income
9340 households are also minority, tribal, or both. Payments to the CTCR, which are based on
9341 Bonneville power sales revenue and generation at Grand Coulee Dam are expected to
9342 increase by approximately 2% to 5%. The Spokane Tribe of Indians will also begin receiving
9343 payments based on Bonneville power sales revenue and generation at Grand Coulee Dam.
9344 That payment is expected to begin in 2021 and under MO3 is expected to increase by
9345 approximately 2% to 5%.

9346 **Navigation and transportation.** Ferry operations on Lake Roosevelt could be affected under
9347 MO3 due to anticipated drawdowns in wet years. In wet years, the Inchelium-Gifford Ferry
9348 on Lake Roosevelt would not be able to operate for approximately 29 days of the year in
9349 total, which is 2 additional days than anticipated under the No Action Alternative in wet
9350 years at this location. This moderate effect would primarily fall on the CTCR community.

9351 **Recreation.** No changes in annual water-based recreation visitation associated with changes in
9352 boat ramp accessibility would occur under MO3.

9353 **Cultural resources.** Effects on traditional cultural properties represent no change relative to the
9354 NAA in Region B under MO3. Kettle Falls sacred site would experience no change relative to
9355 the No Action Alternative.

9356 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
9357 **HARBOR DAMS**

9358 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
9359 Region C under MO3 relative to the No Action Alternative, as follows:

9360 **Fish.** When dams are breached under MO3, reservoir conditions on the Snake River would
9361 transition from reservoirs to a riverine system. Short-term adverse effects are anticipated
9362 for most fish species. Some resident fish, such as white sturgeon and bull trout, may benefit
9363 under this alternative. In addition, long-term increases in the abundance of anadromous
9364 species due to dam breach are anticipated to occur, particularly Snake River runs of Chinook
9365 salmon and steelhead. There would be increased spawning habitat for fall Chinook salmon.
9366 All species of salmon and steelhead are culturally important to Indian tribes and increased
9367 salmon and steelhead returns could result in a major beneficial change. Long-term adverse
9368 effects are anticipated for some non-native resident fish species that prefer reservoir
9369 conditions, such as walleye. Effects on resident fish have the potential to adversely impact
9370 fishing opportunities for Indian tribes, as well as low-income and minority subsistence
9371 fishers in this region.

9372 MO3 mitigation includes:

- 9373 ○ Construct a trap-and-haul facility at McNary and conduct at least two years of trap-and-
9374 haul operations for Snake River fish (Chinook salmon, Sockeye, Steelhead) to allow
9375 removal and transport of these fish from the lower Snake River prior to breaching.
- 9376 ○ Raise additional hatchery fish to help to address two lost year classes of anadromous
9377 fish, prior to the initiation of each phase of breaching (2 phases) of the lower Snake
9378 River dams.
- 9379 ○ Modify the Tucannon River channel at the delta to allow Bull Trout, salmon, and
9380 steelhead passage after lower Snake River water elevations decrease from breaching.
- 9381 ○ On the Snake River, prior to dam breaching, trap-and-haul white sturgeon from
9382 impacted areas to locations in Hells Canyon and downstream of McNary Dam on the
9383 Columbia River.
- 9384 ○ Develop and implement a planting plan for approximately 1500 acres of wetland and
9385 riparian species along the exposed shorelines.
- 9386 ○ Develop and implement a restoration plan for approximately 155 acres of wetlands
9387 downstream of Ice Harbor.

9388 **Power generation and transmission.** Under MO3 upward rate pressure may result in an
9389 increase in the average annual cost of electricity per household in Region C of 0.34 to 6.8
9390 percent, or up to approximately \$61 per year, compared to the No Action Alternative,
9391 depending on the county and the replacement portfolio. For census block groups in low-
9392 income populations, minority populations, or Indian tribes within the study area, this would
9393 represent an increase of approximately 0.067 percent of household income compared to an
9394 increase of 0.035 percent for other households in Region C. As discussed in the No Action
9395 Alternative, energy burdens in Region C are already likely unaffordable for all households
9396 with incomes below the Federal poverty level. Any upward rate pressure could impact low-
9397 income households, but these impacts would occur across the region at levels that would
9398 not be considered disproportionately high and adverse. In some cases, these low-income
9399 households are also minority, tribal, or both.

9400 **Navigation and transportation.** With dam breach, the navigation channel in the Snake River
9401 would not be maintained, eliminating commercial navigation access up the Snake River
9402 resulting in major effect. This would increase costs to shippers across Regions C and D as
9403 discussed in Section 3.10, Transportation and Navigation. These increases would result in
9404 regional economic effects of changes in navigation mode from river to rail and truck, as well
9405 as likely lead to some displacement of workers. Due to the distributed nature of the
9406 navigation industry, while some laborers are likely to be low-income, minority, or members
9407 of tribal communities, these effects do not appear likely to be concentrated in one group or
9408 geographic area. In addition, wheat producers are the primary shippers of commodities on
9409 the shallow-draft Snake River. Based on information from the 2017 Census of Agriculture,
9410 minorities likely make up a very small percentage of wheat producers in Region C; for
9411 example, less than three percent of all farm producers in Region C are Hispanic (NASS
9412 2017). Based on unemployment claims for Washington State, the number of minority

9413 farmworkers in Region C is very small (less than 0.1 percent Hispanic) (WAESD 2019).
9414 Additional analysis of impacts to affected communities is included in Section 3.10.3.5.

9415 **Water supply:**

9416 ○ **Municipal and industrial use.** Under MO3, pumps and wells that supply municipal and
9417 industrial uses in the Lewiston area would no longer be operational once the dams were
9418 breached. Implementation of MO3 could affect access to diversions in the Lewiston area
9419 and other small municipal and industrial uses along the river; approximately 21,330
9420 acre-feet is diverted for municipal and industrial (M&I) purposes. A total of 16 points of
9421 diversion from surface water, which may use up to 9,230 acre-feet per year, and
9422 approximately 63 groundwater wells, which may use up to 12,100 acre-feet could be
9423 affected. These diversions would need to be modified to continue operation after dam
9424 breaching. The water supply analysis models these costs as a decrease in household
9425 income which has a negative impact on the regional economy in terms of jobs, labor
9426 income, and output (sales). These effects were estimated as a loss of 55 jobs, \$2.3
9427 million of labor income, and \$7.5 million of output (sales). Because the effects are minor
9428 (less than 0.5 percent of jobs and labor income in the region), the effects related to a
9429 loss of municipal and industrial water supply are not expected to result in
9430 disproportionately high and adverse effects on minority populations, low-income
9431 populations, or Indian tribes.

9432 ○ **Irrigated farmland.** Under MO3, pumps that supply irrigation in Region C would no
9433 longer be operational once the dams are breached and groundwater elevations could be
9434 substantially impacted. The water supply analysis assumes all 47,840 irrigated acres
9435 receiving water from the current pumps in Region C would no longer be irrigated
9436 because pumps and wells that supply this water would no longer be operational. This
9437 decreased agricultural production is assumed to result in the loss of all employment,
9438 labor income, and output (sales) associated with production of these acres. Compared
9439 to the No Action Alternative, 4,822 jobs are expected to be lost, with a decrease in labor
9440 income and output equal to what was estimated under the No Action Alternative (i.e.,
9441 approximately \$232 million in labor income and output of \$461 million). These jobs are
9442 the result of gross farm income generated from crop production on approximately
9443 47,840 acres of farmland. However, based on unemployment claims for Washington
9444 State, the number of minority farmworkers in counties in the Ice Harbor and Lower
9445 Monumental water supply socioeconomic region is very small (for example, less than
9446 0.1 percent is Hispanic) (WAESD 2019). Given the location of various low-income census
9447 block groups within the Ice Harbor and Lower Monumental area, low-income
9448 populations may be affected by these changes to employment and labor income.
9449 Because the effects are relatively small, the effects on low-income populations, minority
9450 populations and Indian tribes related to a loss in irrigation are not expected to result in
9451 disproportionately high and adverse effects on minority populations, low-income
9452 populations, or Indian tribes.

9453 **Recreation.** Due to dam breaching and construction activities, there would be major adverse
9454 effects to all water- and land-based reservoir visitation from construction closures in the

9455 short-term at the four Lower Snake River projects. This could result in a decrease of 2.6
9456 million annual visits on average in the short term. Some land-based visitation would return
9457 as access to lower Snake River areas is reopened. The reduction of only water-based
9458 reservoir recreation compared to No Action Alternative at the lower Snake river would
9459 result in a decrease of 0.9 million visitors. In the short-term, non-local visitor expenditures
9460 could decrease by approximately \$103 million during construction and breaching activities,
9461 resulting in major adverse effects to regional economic conditions (decrease in 1,230 jobs
9462 and \$39 million in labor income). After the construction and breaching period is over, access
9463 could be re-opened to some of the recreation areas. A reduction in only the reservoir
9464 water-based visitors compared to No Action Alternative could result in a major decrease in
9465 non-local visitor expenditures of \$37 million, with associated decreases in 450 jobs, \$14
9466 million in income, and \$53 million in sales. Over time, river recreation would grow, along
9467 with the quality of the recreational experience. The newly created river conditions would
9468 draw a different pattern of visitors to the region, with different types of visitor spending
9469 compared with reservoir visitors. Depending on the numbers and type of visitor, tourism
9470 economic activity may partially or fully offset the loss in economic activity associated with
9471 reservoir recreation, with the potential for greater economic activity in the region relative
9472 to the No Action Alternative.

9473 In addition to potential changes in regional spending, changes in other social effects
9474 could be major and adverse, particularly in the short term, as communities that are
9475 economically dependent on visitation to the Lower Snake River projects and Lake
9476 Wallula could be adversely affected. However, during the transition period, to the
9477 extent that low-income populations, minority populations or tribal populations in this
9478 region would have participated in the recreation activities or been employed in
9479 recreation-based jobs, impacts to environmental justice populations may occur. While
9480 some recreational participants may be part of low-income populations, minority
9481 populations, and Indian tribes, these populations are not expected to comprise the
9482 majority of these affected visitors. As such, disproportionately high and adverse effects
9483 are not anticipated.

9484 **Cultural resources.** Following dam breach, the Ice Harbor, Lower Monumental, Little Goose,
9485 and Lower Granite projects would experience moderate effects to traditional cultural
9486 properties associated with sediment erosion and deposition. The projects could also
9487 experience increased effects under MO3 associated with public access including looting,
9488 vandalism, creation of trails, and unauthorized activities. At the same time, the return of
9489 this portion of the Snake River to riverine conditions would allow practitioners of traditional
9490 lifeways the chance to return to locations that have been inaccessible for decades. Because
9491 of the unique ties between the landscape and traditional Native American lifeways, this
9492 benefit would be most recognized in tribal communities. Effects to cultural resources would
9493 be mitigated through the ongoing Federal Columbia River Power System program.

9494 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

9495 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
9496 Region D under MO3 relative to the No Action Alternative, as follows:

9497 **Fish.** Short-term increased sedimentation above McNary Dam could have a minor, temporary
9498 adverse effect on fishing conditions. Long-term increases in the abundance of anadromous
9499 recreational fishing species, including Chinook salmon and other salmonids as well as white
9500 sturgeon, are anticipated to occur due to dam breach under MO3. All species of salmon and
9501 steelhead are culturally important to Indian tribes and increased salmon and steelhead
9502 returns could represent a substantial beneficial change.

9503 MO3 mitigation includes:

- 9504 ○ Temporary extension of performance standard spill levels in coordination with the
9505 Regional Forum.
- 9506 ○ If conditions in the tailrace are impeding upstream passage of adult salmon and
9507 steelhead or actionable TDG impacts to fish are observed through real-time monitoring,
9508 the co-lead agencies would implement performance standard spill operations until the
9509 situation is remedied.

9510 **Power generation and transmission.** Under MO3, upward rate pressure may result in an
9511 increase in the average annual cost of electricity per household in Region D of 0.70 to 15
9512 percent, or up to approximately \$130 per year, compared to the No Action Alternative,
9513 depending on the county and the replacement portfolio. For census block groups in low-
9514 income populations, minority populations, or Indian tribes within the study area, this would
9515 represent an increase of approximately 0.14 percent of household income compared to an
9516 increase of 0.10 percent for other households in Region D. As discussed in the No Action
9517 Alternative, energy burdens in Region D are already likely unaffordable for most households
9518 with incomes below the Federal poverty level. Any upward rate pressure could impact low-
9519 income households, but these impacts would occur across the region at levels that would
9520 not be considered disproportionately high and adverse. In some cases, these low-income
9521 households are also minority, tribal, or both.

9522 **Navigation and transportation.** With dam breach, the navigation channel in the Snake River
9523 would be inaccessible for commercial navigation. This would increase costs to shippers
9524 across Regions C and D as discussed in Section 3.10, Transportation and Navigation. These
9525 increases would result in regional economic effects of changes in navigation mode from
9526 river to rail and truck, as well as likely lead to some displacement of workers. While some
9527 laborers are likely to be low-income, minority, or members of tribal communities, these
9528 effects do not appear likely to impact a specific environmental justice population or area.

9529 **Water supply: irrigated farmland.** As described in Section 3.12, *Water Supply*, some areas of
9530 Region D may be affected by increased sediment deposition in water supplies following dam
9531 breach. Large pumps should not be affected, but smaller private pumps may be impacted by
9532 fine-grained material and require more frequent maintenance. However, these would likely

9533 not impact low-income populations, minority populations or Indian tribes. Tribal farming
9534 operations on the Umatilla Indian Reservation would not be expected to be affected, as
9535 their source for irrigation is the Columbia River, which would not be affected under this
9536 alternative (Reclamation 2019).

9537 **Recreation.** Due to breach of Lower Snake River dams, sedimentation impacts along the south
9538 and east banks in Lake Wallula (behind McNary Dam) below the mouth of the Snake River
9539 would reduce annual water-based visitation by 5.6 percent under MO3. This would reduce
9540 visitation by approximately 163,000 annual visits. Sedimentation impacts would likely last
9541 for two to seven years. Overall regional economic effects would be minor. Some recreation
9542 visitation could be replaced or improved based on adaptation over time, as anadromous
9543 fish populations improve; this could include additional river-based recreation visits.
9544 However, during the transition period, to the extent that low-income populations, minority
9545 populations or tribal populations in this region would have participated in the recreation
9546 activities or would have been employed in recreation-based jobs, impacts to environmental
9547 justice populations may occur. While some recreational participants may be part of low-
9548 income populations, minority populations, and Indian tribes, these populations are not
9549 expected to comprise the majority of these affected visitors. As such, disproportionately
9550 high and adverse effects are not anticipated.

9551 **Cultural resources.** Effects to traditional cultural properties are anticipated to be moderate at
9552 John Day as a result of the full pool operational measure. Effects to cultural resources would
9553 be mitigated through the ongoing Federal Columbia River Power System program.

9554 **OTHER – AREAS OUTSIDE OF REGIONS A, B, C, AND D**

9555 Effects to minority populations, low-income populations, or Indian tribes may occur in the other
9556 areas under MO3 relative to the No Action Alternative, as follows:

9557 **Power generation and transmission.** Under MO3, upward rate pressure may result in an
9558 increase in the average annual cost of electricity per household in other areas of 0.062 to
9559 10.4 percent, or up to approximately \$90 per year, compared to the No Action Alternative,
9560 depending on the county and the replacement portfolio. For census block groups in low-
9561 income populations, minority populations, or Indian Tribes within the study area, this would
9562 represent an increase of approximately 0.083 percent of household income compared to an
9563 increase of 0.060 percent for other households in this area. As discussed in the No Action
9564 Alternative, energy burdens in other areas are already likely unaffordable for most
9565 households with incomes below the Federal poverty level. Any upward rate pressure could
9566 impact low-income households, but these impacts would occur across the region at levels
9567 that would not be considered disproportionately high and adverse. In some cases, these
9568 low-income households are also minority, tribal, or both.

9569 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 3**

9570 Through analysis considering effects detailed in Chapter 3 Affected Environment and
9571 Environmental Consequences; Chapter 4 Climate; Chapter 5 Mitigation; and Chapter 6

9572 Cumulative Effects there would not likely be a disproportionately high and adverse effect on
9573 environmental justice populations for MO3.

9574 As discussed in Section 3.7, *Power Generation and Transmission*, Indian tribes could also be
9575 affected by changes in the F&W Program funding under MO3, which would decrease by
9576 approximately \$32 million at least. Given that the lower Snake River dams would no longer be
9577 in place to operate, Bonneville's funding for the effects of construction and operation of these
9578 dams through the Lower Snake River Compensation Plan programs would cease.

9579 **3.18.3.8 Multiple Objective Alternative 4**

9580 Adverse effects related to the following resources are expected under MO4: fish, power
9581 generation and transmission, navigation and transportation, water supply, recreation and
9582 cultural resources. The effects of MO4 on minority populations, low-income populations, or
9583 Indian tribes resulting from changes in these resources are described below by region. Note,
9584 the co-lead agencies engage in ongoing actions to improve conditions for fish, which include,
9585 but are not limited to, habitat restoration, hatcheries, invasive species control, and predator
9586 management.

9587 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

9588 Adverse effects to minority populations, low-income populations, or Indian tribes may occur in
9589 Region A under MO4 relative to the No Action Alternative, as follows:

9590 **Fish.** MO4 would have moderate to major adverse effects to bull trout, westslope cutthroat
9591 trout, and Kootenai River White Sturgeon due to lower reservoir levels in the summer. This
9592 could increase entrainment risk, varial zone effects, and reduce habitat and food availability
9593 in Region A as compared to the No Action Alternative. These effects would increase in dry
9594 years. Indian tribes value these fish for cultural and subsistence uses, and therefore, MO4
9595 has the potential to have adverse effects on Indian tribes in Region A. Low-income and
9596 minority subsistence fishers in the Region could also be affected.

9597 Mitigation under MO4 includes:

- 9598 ○ Implement and expend the existing Invasive Aquatic Plant Removal program at Albeni
9599 Falls.
- 9600 ○ On the Hungry Horse Reservoir, install structural components like woody debris, and
9601 plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to
9602 stabilize the channels, increase cover for migrating fish, and improve the varial zone to
9603 minimize impacts of reservoir fluctuation where the tributaries enter the reservoir.

9604 **Power generation and transmission.** Under MO4 upward rate pressure may result in an
9605 increase in the average annual cost of electricity per household in Region A of 0.041 to 9.1
9606 percent, or up to approximately \$96 per year, compared to the No Action Alternative,
9607 depending on the county and the replacement portfolio. For census block groups in low-
9608 income populations, minority populations, or Indian tribes within the study area, this would

9609 represent an increase of approximately 0.12 percent of household income compared to an
9610 increase of 0.089 percent for other households in Region A. As discussed for the No Action
9611 Alternative, energy burdens in Region A are already likely unaffordable for most households
9612 with incomes below the Federal poverty level. Any downward rate pressure may be helpful
9613 for low-income households; however, energy burdens would likely remain unaffordable.
9614 Any upward rate pressure could impact low-income households, but these impacts would
9615 occur across the region at levels that would not be considered disproportionately high and
9616 adverse. In some cases, these low-income households are also minority, tribal, or both.

9617 **Recreation.** A negligible (less than 1 percent change) in annual water-based recreation
9618 visitation due to effects on boat ramp accessibility at Hungry Horse Reservoir and Lake
9619 Koochanusa would occur under MO4. However, effects to water levels affecting local public
9620 and private docks at Lake Pend Oreille in low water years could have a major adverse effect
9621 on tourism and regional spending. Changes would be similar under low- and high-water-
9622 level years under MO4 relative to the No Action Alternative. Minor adverse effects on the
9623 quality of water-based recreation are expected under MO4. While some recreational
9624 participants may be part of low-income populations, minority populations, and Indian
9625 tribes, these populations are not expected to comprise the majority of these affected
9626 visitors. As such, disproportionately high and adverse effects are not anticipated.

9627 **Cultural resources.** Major effects to traditional cultural properties would be expected at Hungry
9628 Horse as a result of much greater frequency of exposure and increases in frequency of
9629 elevation changes relative to the NAA. The Bear Paw Rock sacred site would experience
9630 greater effects under MO4 relative to the NAA. In drier than normal years, the summer
9631 reservoir elevation for Albeni Falls Dam would be lower than for the No Action Alternative.
9632 Bear Paw Rock would be subject to greater exposure and effects associated with
9633 modifications in access. Effects to cultural resources would be mitigated through the
9634 ongoing Federal Columbia River Power System program.

9635 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

9636 Effects to minority populations, low-income populations, or Indian tribes may occur in Region B
9637 under MO4 relative to the No Action Alternative, as follows:

9638 **Fish.** Resident fish in Region B would experience moderate to major effects in Lake Roosevelt.
9639 This is due to lower retention times resulting in higher entrainment rates and reduced
9640 productivity, as well as increased stranding of kokanee and burbot eggs, and increased
9641 varial zone effects such as tributary access impediments and increased predation risk. In dry
9642 years these effects would be more prominent and there could be adverse water quality
9643 effects to net pen fish and increased invasion of northern pike downstream. Below Chief
9644 Joseph Dam, negligible long-term improvements in Chinook salmon and steelhead are
9645 anticipated based on improved PITPH, as predicted in the LCM model. Any reductions in
9646 latent mortality would increase adult returns predicted by the LCM (there are no CSS model
9647 results available in Region B but increased adult returns associated with reductions in latent
9648 mortality would be consistent with CSS results from other regions). Under MO4, potential

9649 effects to fishing opportunities for Indian tribes, range from moderate adverse to moderate
9650 beneficial in Region B. Low-income and minority subsistence fishers in the Region could also
9651 be similarly affected.

9652 The river mechanics analysis indicates minor increases in the mobility of bed material in
9653 Lake Roosevelt under MO4. If contaminated slag is present in the mobilized bed
9654 material, this could create additional toxicity in fish and other aquatic organisms.
9655 However, the change in potential toxicity is unknown. Reservoir drawdowns of longer
9656 duration under MO4 increase the exposure of shorelines. Increased exposure has the
9657 potential to increase mercury methylation rates, which could lead to greater buildup of
9658 mercury quantities in aquatic organisms (i.e. bioaccumulation) (Willacker 2016).
9659 Populations who rely on subsistence fishing in Lake Roosevelt could be adversely
9660 impacted if the bioaccumulation of heavy metals increases.

9661 Mitigation under MO4 includes developing additional spawning habitat at Lake
9662 Roosevelt to minimize impacts to resident fish.

9663 **Power generation and transmission.** Under MO4 upward rate pressure may result in an
9664 increase in the average annual cost of electricity per household in Region B of 0.25 to 14
9665 percent, or up to approximately \$140 per year, compared to the No Action Alternative,
9666 depending on the county and the replacement portfolio. For census block groups in low-
9667 income populations, minority populations, or Indian tribes within the study area, this would
9668 represent an increase of approximately 0.12 percent of household income compared to an
9669 increase of 0.066 percent for other households in Region B. As discussed in the No Action
9670 Alternative, energy burdens in Region B are already likely unaffordable for most households
9671 with incomes below the Federal poverty level. Any upward rate pressure could impact low-
9672 income households, but these impacts would occur across the region at levels that would
9673 not be considered disproportionately high and adverse. In some cases, these low-income
9674 households are also minority, tribal, or both. Payments to the CTCR, which are based on
9675 Bonneville power sales revenue and generation at Grand Coulee Dam are expected to
9676 increase by approximately 5% to 9%. Spokane Tribe of Indians will also begin receiving
9677 payments based on Bonneville power sales revenue and generation at Grand Coulee Dam.
9678 That payment is expected to begin in 2021 and under MO4 is expected to increase by
9679 approximately 5% to 9%.

9680 **Navigation and transportation.** Ferry operations on Lake Roosevelt could be affected under
9681 MO4 due to anticipated drawdowns in wet years. In wet years, the Inchelium-Gifford Ferry
9682 on Lake Roosevelt would not be able to operate for approximately 36 days of the year,
9683 which is 9 additional days than anticipated under the No Action Alternative in wet years at
9684 this location. The Inchelium-Gifford Ferry is operated by the CTCR, and provides commuters,
9685 schoolchildren, tourists, and others with transportation for daily activities including
9686 commuting to work, accessing health care, and participating in educational activities. When
9687 the ferry is not in service, the next nearest Columbia River crossing is approximately 34
9688 miles to the north on WA20/US395 and WA25/US395. This moderate effect would primarily
9689 fall on the CTCR community.

9690 **Recreation.** A reduction in annual water-based recreation visitation due to effects on boat
9691 ramp accessibility at Lake Roosevelt would occur under MO4. Visitation would decrease by
9692 approximately 45,000 visitor days (6 percent) in high-water-level years and decrease by
9693 approximately 175,000 visitor days (24 percent) in low-water-level years, a major adverse
9694 effect in this region. Changes in the quality of recreational experience are expected to be
9695 both adverse and beneficial. Some portion of the visits to Lake Roosevelt may be
9696 attributable to the low-income populations, minority populations, and Indian tribes
9697 (particularly the Spokane Tribe and the Confederated Tribe of the Colville Reservation,
9698 whose lands border Lake Roosevelt) could experience adverse effects from change in water-
9699 based recreation visitation. While specific visitation by tribal community members in
9700 visitation at Lake Roosevelt is not known, their participation would be captured in local
9701 visitation estimates to the lake. According to the National Park Service, approximately 30
9702 percent of trips to Lake Roosevelt represent local day use trips (those visiting from less than
9703 60 miles away) (Cullinane Thomas 2018). This would equate to approximately 13,500 visits a
9704 year (averaging 36 visits per day) for all local visitors that may be affected under MO4. In
9705 addition to these visits, some portion of the additional non-local visits (70 percent of visits)
9706 are likely to be individuals that are part of low-income populations, minority populations,
9707 and Indian tribes. Overall, environmental justice populations are not expected to comprise
9708 the majority or a substantial portion of affected visitors. As such, these populations are not
9709 expected to experience disproportionately high and adverse effects related to recreation.

9710 **Cultural resources.** Implementation of MO4 could adversely affect traditional cultural
9711 properties through increasing exposure and erosion associated with increased reservoir
9712 level fluctuations.¹⁷ Specifically, MO4 would increase exposure at the Grand Coulee Project
9713 and would increase the frequency and the amplitude of elevation changes, resulting in
9714 major effects to TCPs relative to the NAA at Grand Coulee. Increases in exposure of Hayes
9715 Island (one of the main features at Kettle Falls), due to longer and more frequent drawdown
9716 periods, may lead to potential looting. This increased exposure may also allow some
9717 increased access for tribal religious practitioners, although such temporary access may not
9718 be perceived as beneficial. Effects to cultural resources would be mitigated through the
9719 ongoing Federal Columbia River Power System program.

9720 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
9721 **HARBOR DAMS**

9722 Effects to minority populations, low-income populations, or Indian tribes may occur in Region C
9723 under MO4 relative to the No Action Alternative, as follows:

9724 **Fish.** Under MO4, a wide range of predicted changes to adult salmon and steelhead abundance
9725 vary by model and range from major decreases (LCM without latent mortality effects) to
9726 major increases (CSS). These effects (either adverse or beneficial) would be noticeable to
9727 fishers. All species of salmon and steelhead are culturally important to Indian tribes and
9728 large increases in salmon and steelhead returns could represent a major beneficial change,

¹⁷ The Chief Joseph Project was not analyzed due to a lack of substantial operational or structural changes.

9729 while major adverse impacts to adult abundance would result in the opposite effect. There
9730 may also be increased gas bubble trauma for bull trout and other resident fish in Region C.
9731 Adverse effects to resident fish have the potential to impact fishing opportunities in Region
9732 C. Low-income and minority subsistence fishers in the Region could also be affected by
9733 changes in fishing opportunities.

9734 Mitigation under MO4 includes:

- 9735 ○ Temporary extension of performance standard spill levels in coordination with the
9736 Regional Forum.
- 9737 ○ Modify the Little Goose Raceway infrastructure to de-gas the water in the raceway
9738 during collection for transport. This would allow the fish to be transported in water with
9739 lower TDG than that in the river.

9740 **Power generation and transmission.** Under MO4 upward rate pressure may result in an
9741 increase in the average annual cost of electricity per household in Region C of 0.19 to 8.8
9742 percent, or up to approximately \$79 per year, compared to the No Action Alternative,
9743 depending on the county and the replacement portfolio. For census block groups in low-
9744 income populations, minority populations, or Indian tribes within the study area, this would
9745 represent an increase of approximately 0.084 percent of household income compared to an
9746 increase of 0.044 percent for other households in Region C. As discussed in the No Action
9747 Alternative, energy burdens in Region C are already likely unaffordable for all households
9748 with incomes below the Federal poverty level. Any upward rate pressure could impact low-
9749 income households, but these impacts would occur across the region at levels that would
9750 not be considered disproportionately high and adverse. In some cases, these low-income
9751 households are also minority, tribal, or both.

9752 **Navigation and transportation.** Effects on navigation and transportation, are anticipated to be
9753 negligible in Region C under MO4, given that only average annual costs for commercial
9754 navigation are anticipated to slight decrease.

9755 **Water supply.** No changes from the No Action Alternative are anticipated in Region C under
9756 MO4.

9757 **Recreation.** No changes in annual water-based recreation visitation associated with changes in
9758 boat ramp accessibility would occur under MO4.

9759 **Cultural resources.** Effects to traditional cultural properties are anticipated to be minor at
9760 Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. Effects to cultural
9761 resources would be mitigated through the ongoing Federal Columbia River Power System
9762 program.

9763 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

9764 Effects to minority populations, low-income populations, or Indian tribes may occur in Region D
9765 under MO4 relative to the No Action Alternative, as follows:

9766 **Fish.** Under MO4, a wide range of predicted changes to adult salmon and steelhead abundance
9767 vary by model and range from moderate decreases (LCM) to substantial increases (CSS).
9768 These effects (either adverse or beneficial) would be noticeable to fishers. All species of
9769 salmon and steelhead are culturally important to Indian tribes and increased salmon and
9770 steelhead returns could represent a major beneficial change, while major adverse effects to
9771 adult returns would result in the opposite effect. Increased TDG and lower Columbia River
9772 drawdowns could reduce fish habitat availability for resident fish. Adverse effects on
9773 resident fish have the potential to affect fishing opportunities in Region D. Low-income and
9774 minority subsistence fishers in the Region could also be affected by changes in fishing
9775 opportunities.

9776 Mitigation under MO4 includes the temporary extension of performance standard spill levels in
9777 coordination with the Regional Forum.

9778 **Power generation and transmission.** Under MO4 upward rate pressure may result in an
9779 increase in the average annual cost of electricity per household in Region D of 0.35 to 18
9780 percent, or up to approximately \$160 per year, compared to the No Action Alternative,
9781 depending on the county and the replacement portfolio. For census block groups in low-
9782 income populations, minority populations, or Indian tribes within the study area, this would
9783 represent an increase of approximately 0.17 percent of household income compared to an
9784 increase of 0.12 percent for other households in Region D. As discussed in the No Action
9785 Alternative, energy burdens in Region D are already likely unaffordable for most households
9786 with incomes below the Federal poverty level. Any upward rate pressure could impact low-
9787 income households, but these impacts would occur across the region at levels that would
9788 not be considered disproportionately high and adverse. In some cases, these low-income
9789 households are also minority, tribal, or both.

9790 **Navigation and transportation.** As discussed in Section 3.10, Transportation and Navigation,
9791 effects on navigation and transportation are anticipated to be negligible in Region D under
9792 MO4 given that average annual cost increases would represent less than 0.1 percent of
9793 total costs of navigation operations.

9794 **Water supply: Irrigated farmland.** Changes in pumping efficiencies related to drawdowns of
9795 the John Day Reservoir in Region D would result in increased pumping costs to meet
9796 irrigation needs; these additional total annual energy costs are estimated to range from
9797 \$260,000 to \$277,000. This increased spending is expected to result in an average annual
9798 decrease in employment (fewer than five jobs) and labor income (\$55,000 to \$59,000) and
9799 output (\$176,000 to \$188,000). These effects represent less than 0.01 percent of jobs and
9800 labor income in the John Day water supply region.

9801 **Recreation.** No changes in annual water-based recreation visitation associated with changes in
9802 boat ramp accessibility would occur under MO4.

9803 **Cultural resources.** Implementation of MO4 could adversely affect traditional cultural
9804 properties through increasing exposure and erosion associated with increased reservoir
9805 level fluctuations. However, these effects are expected to be minor relative to the NAA at

9806 the four projects in this region. Effects to cultural resources would be mitigated through the
9807 ongoing Federal Columbia River Power System program.

9808 **OTHER – AREAS OUTSIDE OF REGIONS A, B, C, AND D**

9809 Because effects on resources would be primarily limited to Regions A, B, C, and D, effects on
9810 minority populations, low-income populations, or Indian tribes outside of Regions A, B, C, and D
9811 would not be anticipated relative to the No Action Alternative under MO4 other than for power
9812 generation and transmission.

9813 **Power generation and transmission.** Under MO4, upward rate pressure may result in an
9814 increase in the average annual cost of electricity per household in other areas of 0.062 to 11
9815 percent, or up to approximately \$110 per year, compared to the No Action Alternative,
9816 depending on the county and the replacement portfolio. For census block groups in low-
9817 income populations, minority populations, or Indian tribes within the study area, this would
9818 represent an increase of approximately 0.072 percent of household income compared to an
9819 increase of 0.055 percent for other households in this area. As discussed for the No Action
9820 Alternative, energy burdens in other areas are already likely unaffordable for most
9821 households with incomes below the Federal poverty level. Any upward rate pressure could
9822 impact low-income households, but these impacts would occur across the region at levels
9823 that would not be considered disproportionately high and adverse. In some cases, these
9824 low-income households are also minority, tribal, or both.

9825 **SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 4**

9826 Through analysis considering effects detailed in Chapter 3 Affected Environment and
9827 Environmental Consequences; Chapter 4 Climate; Chapter 5 Mitigation; and Chapter 6
9828 Cumulative Effects there would not likely be a disproportionately high and adverse effect on
9829 environmental justice populations for MO1.

9830 **3.19 IMPLEMENTATION AND SYSTEM COST ANALYSIS**

9831 The purpose of the cost analysis is to provide an estimate of the total cost for implementing,
9832 operating and maintaining the system under each of the MOs. The emphasis of the cost
9833 analysis is to understand the cost differences among the alternatives, particularly between the
9834 proposed MOs and the No Action Alternative. Implementation costs include the costs of
9835 constructing proposed structural measures under the MOs. All alternatives including the NAA
9836 have costs associated with operating and maintaining the Columbia River System, costs that
9837 may change relative to the structural and/or operational measures included under an MO.
9838 These on-going future costs include capital investments, routine and non-routine operations
9839 costs (including extraordinary maintenance (NREX)), and mitigation costs including fish and
9840 wildlife programs costs. For the purpose of the cost analysis, these future costs are referred to
9841 as “system costs.”

9842 The cost analysis is focused on 14 Federal multiple purpose dams (projects), reservoirs, and
9843 navigation channels known as the Columbia River System (CRS).

9844 The cost analysis presents annual equivalent costs over the 50-year period of analysis in 2019
9845 dollars.¹ For consistency across alternatives, construction of the structural measures is assumed
9846 to begin in 2021 and occur over a 2-year period. However, given the uncertainty around the
9847 potential implementation timing for a complex alternative such as the dam breaching
9848 alternative (MO3), a sensitivity analysis was completed to determine the effect of construction
9849 timing on costs (described further below and in Appendix Q, *Cost Analysis*). Additionally, it
9850 should be noted that there are multiple areas of uncertainty related to the cost analysis in
9851 general. These include factors such as utilizing preliminary or planning level designs for
9852 structural measures; assessing capital costs and operations and maintenance (O&M) cost
9853 estimates based on these designs; as well as the uncertainty related to implementation or
9854 construction timing that would affect cost estimates.

9855 The following section provides a summary of the cost analysis methodology, followed by a
9856 section summarizing cost analysis results. Additional details regarding the multi-step process
9857 employed to complete the cost analysis, including the data collected, cost engineering details
9858 and related information is presented in Appendix Q, *Cost Analysis*. The appendix also provides
9859 detailed cost results for each action alternatives as well as the methods and results of a regional
9860 economic impact evaluation (Annex C of Appendix Q). The regional economic impact analysis
9861 estimates the jobs and income associated with implementation and system costs under the No
9862 Action Alternative and action alternatives.

¹ The federal water resources discount rate of 2.75% was used in the discounting process and to amortize the costs to annual equivalent costs (Corps, EGM 20-1, Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2020).

9863 **3.19.1 Summary of Cost Analysis Methodology**

9864 The No Action Alternative provides a baseline for understanding the costs associated with
9865 operating and maintaining the CRS under its current configuration and operation regime. The
9866 No Action Alternative also provided a starting point for identifying how costs would change as
9867 various structural or operational changes or both are made under MOs. The No Action
9868 Alternative was developed with extensive input from experts across the three co-lead agencies
9869 (Bonneville, Reclamation, and the Corps). A comprehensive accounting of all costs required to
9870 operate and maintain the CRS was developed based upon historic, current and anticipated
9871 future expenditures. The cost categories shown in Table 3-307 account for all implementation
9872 and system costs. The costs are broadly grouped by construction of structural measures
9873 (implementation costs), capital and O&M costs, and mitigation costs.

9874 Under the No Action Alternative it was assumed the CRS would continue to be operated in a
9875 manner similar to current operations, balancing operations for congressionally authorized
9876 purposes across the CRS. Under the No Action Alternative, co-lead agencies will continue to
9877 make large capital investments in power-related improvements, additions, and replacements,
9878 as needed, to meet reliability standards, efficiency needs, environmental requirements, safety
9879 and security standards, and other requirements. In addition, non-routine and routine O&M
9880 costs would continue to meet system requirements; these include non-routine extraordinary
9881 maintenance (NREX) costs (both power and joint), and non-routine navigation costs, while
9882 routine O&M costs would occur for hydropower, cultural resources, navigation, recreation, fish
9883 and wildlife, and other routine costs.

9884 Current operations include mitigation activities, actions agreed to in previous ESA consultations
9885 among the co-lead agencies, NMFS, and USFWS. The Bonneville F&W Program funds hundreds
9886 of projects each year to mitigate the impacts of the development and operation of the Federal
9887 hydropower system. In addition, the Corps and the Reclamation provide funding for fish and
9888 wildlife mitigation measures and activities under obligations including the ESA. The Corps uses
9889 CRFM appropriations to fund mitigation for fish and wildlife construction activities, while
9890 Reclamation funds habitat improvement, hatcheries and monitoring activities. Bonneville funds,
9891 either directly to the Corps and Reclamation or as a reimbursement to the U.S. Treasury, for the
9892 power share of mitigation activities, such as hatchery operations, fish stocking, elk habitat
9893 maintenance, and others.

9894 After the No Action Alternative costs were established, the costs for each for the structural
9895 measures included in the MOs were developed by the cost engineers at the Corps Mandatory
9896 Cost Center of Expertise at the Walla Walla District. Next, an extensive evaluation was
9897 conducted on how the structural and operational measures under each of the MOs would
9898 affect the capital costs and routine and non-routine operations and maintenance costs
9899 compared to the No Action Alternative. Once these changes were estimated, they were
9900 reviewed by operations and/or project staff to ensure estimates were consistent with their
9901 knowledge of system operations and related costs.

9902

9903 **Table 3-307. Cost Components and Descriptions**

Cost Category		Description	Source
Construction of Structural Measures	Structural Measure Costs of the MOs	The construction costs (and contingency) of the structural measures associated with the alternatives, as well as supervision, administration, and engineering during construction, and real estate administrative costs (Bonneville, Corps, and Reclamation).	Corps Cost Engineering Center of Expertise
Capital and O&M Costs	Capital Costs (Power Specific and Joint)	Bonneville-funded large and small capital costs associated with additions, improvements and replacements for hydropower equipment as well as the Bonneville's funded portion of "joint" features that serve multiple purposes at the 14 Federal projects. Includes Corps and Reclamation share of joint costs (often called joint tail) for large and small capital costs for the 14 Federal dams in the Columbia River Basin	Federal Columbia River Power System 2018 Strategic Asset Management Plan (SAMP); Corps District and Bureau of Reclamation resource and budget specialists
	Non-routine Extraordinary Maintenance (NREX) Costs (Power Specific and Joint)	Bonneville's power specific and joint costs for non-routine extraordinary maintenance, such as costs for repair of a failed units. Includes the Corps and Bureau of Reclamation joint cost share (often called joint tail) for NREX costs for the 14 Federal dams in the Columbia River Basin	Bonneville Resource Economic Planners; Corps District and Bureau of Reclamation resource and budget specialists
	Hydropower Routine O&M	The costs associated with the routine operations and maintenance of the hydropower portion of the 14 Columbia River Projects (Bonneville).	Corps of Engineers Financial Management System, queried by AMSCO code, CCS, for past five fiscal years; Reclamation budget experts
	Navigation Routine O&M Costs	The costs that are typically associated with routine operations and maintenance of the locks that regularly occurs, such as lock maintenance (Corps).	Corps of Engineers Financial Management System, queried by AMSCO code, CCS, for past five fiscal years; Reclamation budget experts
	Recreation Routine O&M	The costs associated with routine operations and maintenance recreation facilities at the 14 Federal projects, including park ranger salaries (Corps and Reclamation).	Corps of Engineers Financial Management System, queried by AMSCO code, CCS, for past five fiscal years ; Reclamation budget experts
	Fish and Wildlife Routine O&M	The costs associated with routine fish and wildlife activities, such as fish ladder maintenance, trapping and transport, and biologists' salaries at the 14 Federal projects (Corps, Reclamation, and Bonneville).	Corps of Engineers Financial Management System, queried by AMSCO code, CCS, for past five fiscal years ; Reclamation budget experts
	Cultural Resources Routine O&M	The costs associated with routine activities for cultural resource protection, such as the costs to preserve and maintain historic cultural sites or practices, and salaries for cultural resource and Native American specialists (Corps, Reclamation, and Bonneville)	Corps of Engineers, Bonneville, and Reclamation cultural resource specialists; Federal Columbia River Power System Fiscal Year 2018 Annual Report
	Other Routine O&M	The Other O&M category includes routine costs, such as regular facilities upkeep, security equipment, salaries for guards, and general grounds maintenance (Corps, Reclamation and Bonneville).	Corps of Engineers Financial Management System, queried by AMSCO code, CCS, for past five fiscal years; Reclamation budget experts
	Non-routine Navigation	The costs associated with maintaining the navigation portion of the dams and locks for navigation at the 4 Columbia and 4 Lower Snake River projects, including dredging and lock and dam costs (Corps).	Corps operations technical specialists and asset managers

Cost Category	Description	Source	
Mitigation Costs ^{1/}	Bonneville Fish and Wildlife (F&W) Program	Bonneville provides funding to multiple local, state, tribal, and Federal entities as part of its fish and wildlife program to implement “offsite mitigation” actions listed in various Biological Opinions for ESA-listed species. ^{2/} The Bonneville F&W Program also funds efforts to protect, mitigate, and enhance fish and wildlife, including non-listed species, affected by the development and operation of the FCRPS, which includes the CRS, under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act) (16 USC 839b (h)(10)(A)). This category only includes non-capital expenses; Bonneville F&W program capital costs, such as hatchery construction, are analyzed as part of the Power and Transmission chapter.	Bonneville budget specialists
	Lower Snake River Compensation Plan (LSRCP)	Congress authorized the LSRCP as part of the Water Resources Development Act of 1976 (90 Stat.2917) to offset fish and wildlife losses caused by construction and operation of the four Lower Snake River dams. A major component of the authorized plan was the design and construction of fish hatcheries and satellite facilities. Bonneville directly funds USFWS for the annual operation and maintenance of these LSRCP facilities ² .	Bonneville budget specialists
	Columbia River Endangered Species Act (ESA) Mitigation	These funds are used to meet the Reclamation ESA requirements, including mitigation commitments in coordination and administration; hydrosystem management; hatcheries; research monitoring and evaluation; tributary habitat improvement projects; and predation management (Reclamation).	Reclamation Program Specialists
	Columbia River Fish Mitigation (CRFM)	These costs are part of the Corps Construction account for fish mitigation activities to meet the Corps obligations under the Biological Opinion (Corps)	Corps Northwestern Division Fish Program Managers
	Costs of Additional Mitigation Measures under the MOs	Mitigation measures were developed that would mitigate adverse impacts of the MOs. Construction or annual costs as well as any relevant O&M and non-routine costs were developed for additional mitigation measures from input from Bonneville, Corps, and Reclamation specialists.	Corps cost engineers from the Cost Engineering Center of Expertise

9904 1/ Please note that some of the fish and wildlife mitigation costs are included in the fish and wildlife routine O&M cost category, such as Dworshak and John Day hatchery production, and timber and elk management.

9905 2/ Over the last decade, the co-lead agencies have spent tens of millions of dollars to improve the quantity and quality of fish habitat in the estuary and tributaries as “offsite mitigation” for the residual adverse effects of system water management on migrating
9906 salmon and steelheads as well as resident fish. These actions typically address impacts to fish not caused by the Columbia River System, but are things the Co-lead Agencies can do to improve the overall conditions for fish to help address uncertainty related to any
9907 residual adverse effects of Columbia River System management on fish species.

² The only funding of the LSRCP assumed under the No Action Alternative is Bonneville’s direct funding of the Program. The Corps’ construction and implementation activities associated with the LSRCP are complete, and no additional funds are anticipated under this authorization.

9908 Additional mitigation measures were also developed under the MOs that would mitigate
9909 adverse impacts (for additional detail, please refer to Chapter 5 of the EIS and Annex B of the
9910 Cost Analysis appendix). The measures were identified after the resource evaluations and
9911 include reasonably foreseeable activities that could be undertaken to avoid, minimize, or
9912 mitigate adverse impacts from occurring under the MOs. These activities may include
9913 protecting cultural resources, improving or mitigating fish and wildlife or water quality impacts
9914 under the breach scenario, among others. The costs for these additional mitigation measures
9915 were estimated by the cost engineers at the Mandatory Cost Center for Expertise with input
9916 from Corps, Reclamation, and Bonneville specialists.³

9917 **3.19.2 Summary of Columbia River System Operations Implementation and System Costs**

9918 A summary of the estimated costs and cost differences among the MOs is provided in this
9919 section. A detailed presentation of costs by project and cost category is provided in Appendix Q,
9920 *Cost Analysis*.

9921 As shown in Table 3-308, the estimated total cost for operating and maintaining the CRS under
9922 the No Action Alternative is approximately \$1.06 billion annually. As described in the previous
9923 section, the No Action Alternative costs include capital, O&M and mitigation costs. Mitigation
9924 costs include the Bonneville F&W Program; Bonneville's funding of the LSRCP; the Corps
9925 Columbia River Fish Mitigation (CRFM) costs; Reclamation ESA-related costs; as well as
9926 additional measures to mitigate adverse effects under the MOs (includes fish and wildlife,
9927 water quality, cultural resources, public safety, and others). Across these general cost
9928 categories under the No Action Alternative, capital costs accounts for 23 percent of total annual
9929 system costs, O&M accounts for 45 percent of total annual system costs, and mitigation
9930 accounts for 31 percent of total annual system costs.

9931 MO1 represents a relatively small increase in annual-equivalent costs when compared to the
9932 No Action Alternative. Under MO1 there would be an estimated increase of \$21 million
9933 annually, or 2 percent compared to No Action Alternative (Table 3-308 and Table 3-309). This
9934 cost increase is driven primarily by construction of structural measures. Present value of the
9935 structural measure costs for MO1 structural measures are estimated to be \$533 million. When
9936 amortized over the 50-year period of analysis, the annual equivalent cost is approximately
9937 \$20.0 million (or 95 percent of the annual cost increase). Almost half of this cost would occur at

³ The Preferred Alternative is being coordinated for consultation with the USFWS and NMFS. Section 7.5, 7.6 of the Preferred Alternative chapter of the EIS describes the specific measures added for ESA compliance. A number of the ESA measures would be implemented through existing funding mechanisms, for example, through the Bonneville F&W Program or the CRFM program, while others would require additional appropriations or funding sources. Therefore, it is expected that there would be some small additional annual costs for ESA compliance measures. Note, that these costs are not included in the mitigation costs summarized in Table 3-308 and 3-309. This is because a number of the measures would likely be implemented under existing programs and funding sources. Additionally, some of the specific measures and implementation plans are still being established through consultation with USFWS and NMFS. Although the focus of the consultation is on the Preferred Alternative, it is expected that the ESA-compliance measures would be similar across the action alternatives (i.e. the Preferred Alternative and the MOs).

9938 the McNary project (\$253.8 million in first costs for all structural measures at McNary), where a
9939 number of fish-related measures would be constructed, followed by similar fish-related
9940 measures at the Ice Harbor project (\$114.2 million in first costs).⁴ There would be slight
9941 changes to capital and O&M costs from the structural measures and operational changes under
9942 MO1, while fish and wildlife mitigation costs are expected to be similar to No Action Alternative
9943 (i.e., Bonneville F&W Program, LSRCP, CRFM, and the Reclamation ESA-related mitigation
9944 would continue). MO1 would also include additional mitigation measures as described in
9945 Section 5.4.1 and Annex B of the Cost Analysis appendix.

9946 As shown in Table 3-308, MO2 is estimated to cost between \$53 to \$106 million more annually
9947 than the No Action Alternative (5 to 10 percent increase). Under MO2, power generation would
9948 increase and juvenile fish passage spill would be reduced. MO2 cost increases are driven by
9949 construction costs of structural measures estimated to be \$1.4 billion (present values of the
9950 cost of the structural measures). Much of the increase in costs for the structural measures
9951 under MO2 compared to MO1 occurs at McNary (powerhouse surface passage first cost under
9952 MO2 is \$889 million versus \$158 million under MO1), where additional surface passage would
9953 include construction of a collection channel and dewatering facility. There would be related
9954 increases in capital and O&M costs from the structural measures and operational changes
9955 under MO2. If the operational measures under MO2 have a negative effect on fish, there could
9956 be an increased need for off-site mitigation funded through the Bonneville F&W Program
9957 (Bonneville 2019). Potential increases to the Bonneville F&W Program are estimated to range
9958 from the same as No Action Alternative up to \$53 million above the No Action Alternative
9959 budget of \$281 million. Funding decisions for the Bonneville F&W Program are not being made
9960 as a part of the CRSO EIS process. However, a range of potential F&W Program costs is included
9961 to inform the broader cost analysis. By analyzing a range of costs, Bonneville reflects the year-
9962 to-year fluctuations related to managing its F&W Program and acknowledges the uncertainty of
9963 both the magnitude of biological effects and the potential impacts on funding, including the
9964 timing of funding decisions. Future budget adjustments would be made in coordination with
9965 the region through Bonneville's budget-making processes and other appropriate forums,
9966 consistent with existing agreements. LSRCP, CRFM, and Reclamation ESA-related mitigation
9967 would remain the same as under the No Action Alternative. Some additional MO2 mitigation
9968 actions are proposed as described in Section 5.4.2 and Annex B of the Cost Analysis appendix.

9969 Under MO3, total costs are anticipated to decrease between \$159 and \$54 million annually, or
9970 between 15.1 to 5.1 percent decline compared to the No Action Alternative (Table 3-309). The
9971 present value of the construction of the structural measures for MO3 are estimated to be \$1.2
9972 billion. Of the \$1.2 billion, \$994 million (or 77 percent) are costs associated with breaching the
9973 Lower Snake River dams. When amortized over the 50-year period of analysis, the annual
9974 equivalent cost is approximately \$46 million (\$35 million for the costs for breaching the Lower
9975 Snake River dams). A sensitivity analysis was conducted on the timing of the construction of the

⁴ It should be noted that after the preferred alternative is chosen, specific changes to Bonneville's F&W Program funding levels would be assessed through future studies and processes as the details of the alternative are refined. Substantial regional coordination would be needed to determine future priorities and associated funding levels. See appendix Q.

9976 structural measures in terms of its impact on annualized costs under MO3, comparing the cost
9977 of completing MO3 over a 10-year timeframe, versus the two-year implementation assumption.
9978 Delaying and spreading out costs for breaching the Lower Snake River dams would result in a
9979 change in annual equivalent costs of \$3.6 million (from \$45.7 million with a two-year
9980 implementation to \$42.1 million with a 10-year implementation schedule) or a 0.4 percent
9981 reduction in total annual-equivalent costs under MO3. This difference in cost (\$3.5 million)
9982 represents approximately 8 percent of the construction costs of the structural measures and
9983 0.4 percent of total annual-equivalent costs under MO3. The difference between a two-year
9984 and a ten-year implementation schedule does not warrant deviation from the two-year
9985 approach used throughout the study.

9986 MO3 would result in a large decrease in capital costs (\$32 million or 13 percent) and O&M costs
9987 (\$79 million or 16.5%) across all projects compared to the No Action Alternative, with the
9988 largest decrease at the Lower Snake River projects (Ice Harbor, Lower Monumental, Little
9989 Goose, and Lower Granite) (Table 3-309). Upon the breaching of the LSR dams, Bonneville
9990 would no longer have an obligation to fund USFWS for O&M of the LSRCP facilities, estimated
9991 at \$34 million. Bonneville's funding authority is directly tied to the operation of the LSR dams.
9992 However, the co-lead agencies recognize that there would be transitional needs that would be
9993 addressed. Additionally, the Bonneville F&W Program funding for offsite mitigation projects in
9994 the Snake River Basin would be reviewed and potentially adjusted. Any changes of this nature
9995 would be implemented over time as the effectiveness of dam breaching is observed, and would
9996 be done in consultation with fish and wildlife managers, regulatory agencies, and the
9997 Northwest Power and Conservation Council. Consistent with this, offsite mitigation projects for
9998 the other CRS dams would be reviewed and could be adjusted as operations change over time.
9999 As a result, Bonneville's F&W Program costs are estimated as a range: from the same as under
10000 the No Action Alternative to a 37 percent decrease, or a decrease of \$105 million annually
10001 when compared to the No Action Alternative. Future budget adjustments would be made in
10002 coordination with the region through Bonneville's budget-making processes and other
10003 appropriate forums and consistent with existing agreements. The CRFM costs would also
10004 decrease under MO3 by \$1.0 million annually, while the Reclamation's ESA-related costs would
10005 remain the same as under the No Action Alternative (\$14.3 million per year).

10006 Additional mitigation costs to offset the adverse impacts of MO3 are estimated to be \$45.7
10007 million annually. The largest mitigation costs would occur at the Lower Snake River projects,
10008 including measures for vegetation, wildlife, wetlands, and floodplains; water quality; cultural
10009 resources; anadromous fish; resident fish; public safety; navigation and transportation; and
10010 other mitigation measures. Details on the additional mitigation measures are described in
10011 Section 5.4.3 and Annex B of the Cost Analysis Technical Appendix.

10012 Estimated MO4 costs range from a decrease in annual costs of \$55 million to an increase in
10013 annual costs of \$50 million, or a -5.2 percent decrease to 4.7 percent increase compared to the
10014 No Action Alternative (Table 3-309). MO4 includes \$1.2 billion (present value) for the
10015 construction of the structural measures, or \$44 million annually. MO4 includes powerhouse
10016 surface passage measures as well as spillway weir notch inserts at all Lower Snake River,

10017 McNary and John Day projects (which are not included under the other MOs) along with several
10018 other fish-related measures similar to those included under MO1. There would be slight
10019 changes to capital and operating and maintenance costs from the structural measures and
10020 operational changes under MO4. Bonneville included a range of potential F&W Program costs
10021 to acknowledge the possibility that MO4 could provide biological benefits to fish and wildlife
10022 and that this could, in turn, reduce the need for some offsite mitigation funded by the
10023 Bonneville F&W Program. As a result, offsite mitigation projects in the Bonneville F&W Program
10024 would be reviewed and could be adjusted as operations change over time. As a result,
10025 Bonneville's F&W Program costs are estimated to range from no change from No Action
10026 Alternative to a decrease of approximately 37 percent, or approximately \$105 million, annually.
10027 Future budget adjustments would be made in coordination with the region through
10028 Bonneville's budget-making processes and other appropriate forums and consistent with
10029 existing agreements. The LSRCP, CRFM, F&W O&M, and the Reclamation ESA-related mitigation
10030 would remain the same as under the No Action Alternative.

10031

10032 **Table 3-308. Annual-equivalent Costs under the Alternatives (\$2019)**

Alternative	Construction Costs of Structural Measures (present value)	Construction Costs of Structural Measures (annual)	Capital Costs (annual)	O&M Costs (annual)	Mitigation (Low F&W Costs) (annual)	Mitigation (High F&W Costs) (annual)	Annual-Equivalent Costs (Low F&W costs)	Annual-Equivalent Costs (High F&W costs)
NAA	NA	NA	\$245,000,000	\$478,000,000	\$332,000,000	\$332,000,000	\$1,055,000,000	\$1,055,000,000
MO1	\$533,000,000	\$20,000,000	\$245,000,000	\$478,000,000	\$333,000,000	\$333,000,000	\$1,076,000,000	\$1,076,000,000
MO2	\$1,412,000,000	\$52,000,000	\$245,000,000	\$477,000,000	\$334,000,000	\$387,000,000	\$1,108,000,000	\$1,161,000,000
MO3	\$1,235,000,000	\$46,000,000	\$213,000,000	\$399,000,000	\$238,000,000	\$343,000,000	\$896,000,000	\$1,001,000,000
MO4	\$1,200,000,000	\$44,000,000	\$245,000,000	\$478,000,000	\$233,000,000	\$338,000,000	\$1,000,000,000	\$1,105,000,000

10033 **Table 3-309. Change in Annual-equivalent Costs under the Multiple Objective Alternatives compared to the No Action Alternative (\$2019)**

10034

MO	Construction Costs of Structural Measures (annual)	Change in Capital Costs (annual)	Change in O&M Costs (annual)	Change in Annual Mitigation (Low F&W Costs)	Change in Annual Mitigation (High F&W Costs)	Change in Total Annual-Equivalent Costs (Low F&W costs)	Percent Change in Annual-Equivalent Costs (Low F&W costs)	Change in Total Annual-Equivalent Costs (High F&W costs)	Percent Change in Annual-Equivalent Costs (High F&W costs)
MO1	\$20,000,000	\$0	\$0	\$1,000,000	\$1,000,000	\$21,000,000	2.0%	\$21,000,000	2.0%
MO2	\$52,000,000	\$0	-\$1,000,000	\$2,000,000	\$55,000,000	\$53,000,000	5.0%	\$106,000,000	10.0%
MO3	\$46,000,000	-\$32,000,000	-\$79,000,000	-\$94,000,000	\$11,000,000	-\$159,000,000	-15.1%	-\$54,000,000	-5.1%
MO4	\$44,000,000	\$0	\$0	-\$99,000,000	\$6,000,000	-\$55,000,000	-5.2%	\$50,000,000	4.7%

10035